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FINAL COMPREHENSIVE SAMPLING AND ANALYSIS PLAN RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION VOLUME 2 OF 5 CNC CHARLESTON SC

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ENSAFE/ ALLEN AND HOSHALL

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA
CTO-029

FINAL COMPREHENSIVE SAMPLING AND ANALYSIS PLAN (CSAP) RCRA FACILITY INVESTIGATION

Prepared for:

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CHARLESTON, SOUTH CAROLINA

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Release of this document requires the prior notification of the Commanding Officer of the Naval Base Charleston, Charleston, South Carolina.

VOLUME II

ACRONYM LIST

AASHTO	American Association of State Highway and Transportation Officials
AOC	Area of Concern
ASTM	American Society of Testing and Materials
AWQC	Ambient Water Quality Criteria
bls	below land surface
CAMU	Corrective Action Management Unit
CFR	Code of Federal Regulations
CHASP	Health and Safety Plan
CLEAN	Comprehensive Long-term Environmental Action Navy
CLP	Contract Laboratory Program
cm	centimeter
COC	Contaminant of Concern
COLIWASA	composite liquid waste sampler
CSAP	Comprehensive Sampling and Analysis Plan
CTO	Control Task Order
CWA	Clean Water Act
°C	degrees Centigrade
DE	disposable equipment
DMP	Data Management Plan
DOT	Department of Transportation
DQO	Data Quality Objective
DRMO	Defense Reutilization and Marketing Office
DS3	Datasonde 3
E/A&H	EnSafe/Allen & Hoshall
EIC	Engineer in Charge
EM	Electromagnetic
EPROM	Erasable Programmable Read Only Memory
ESDLOPQCM	USEPA Environmental Services Division *Laboratory Operations and Quality Control Manual* (1990)
ESDSOPQAM	USEPA Environmental Services Division *Standard Operating Procedures and Quality Assurance Manual* (1991)
FID	Flame Ionization Detector
ft^3	cubic feet
GC	Gas Chromatograph
GIS	Geographic Information System
gpm	gallons per minute
GPS	Global Positioning System
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCl	Hydrochloric Acid
HSWA	Hazardous and Solid Waste Amendment
IATA	International Air Transport Association
ID	Inner Diameter
IDL	Instrument Detection Limit
IDW	Investigation-Derived Waste

IRP	Installation Restoration Program
KI	Potassium Iodide
LCD	Liquid Crystal Display
LDR	Land Disposal Restrictions
LQAC	Laboratory Quality Assurance Coordinator
ml	Milliliter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
msl	Mean Sea Level
MTR	Minimum Technical Requirements
NAD	North American Datum
NaI	Sodium Iodide
NaOH	Sodium Hydroxide
NAVBASE	Naval Base Charleston
NBS	National Bureau of Standards
NCP	National Oil and Hazardous Substances Contingency Plan
NCR	NEESA Contract Representative
NEESA	Naval Energy and Environmental Support Activity
NIST	National Institute of Standards and Technology
NPDES	National Pollution Discharge Elimination System
NSF	National Sanitary Foundation
NTU	Nephelometric Turbidity Unit
OD	Outer Diameter
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	Organic Vapor Analyzer
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PCP	Pentachlorophenol
PID	Photoionization Detector
PMP	Project Management Plan
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
ppm	parts per million
PVC	polyvinyl chloride
QA	Quality Assurance
QAP	Quality Assurance Plan
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RAM	Random Access Memory
RCRA	Resource Conservation and Recovery Act
redox	oxidation/reduction potential
RI/FS	Remedial Investigation/Feasibility Study
RFI	RCRA Facility Investigation
RPD	Relative Percent Difference
RT	Regulatory Threshold

SAP	Sample and Analysis Plan
SCDHEC	South Carolina Department of Health and Environmental Control
SOUTHNAVFACENGCOM	Southern Division Naval Facilities Engineering Command
SVOC	Semivolatile Organic Compound
SW-846	USEPA *Test Methods for Evaluating Solid Waste*, 3rd. ed. (1986)
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TD-MS	Thermal Desorption-Mass Spectrometry
TD-GC/MS	Thermal Desorption-Gas Chromatograph/Mass Spectrometry
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TU	Temporary Unit
USCS	Unified Soil Classification Scheme
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound

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1.0 INTRODUCTION

This document is intended to function as the Comprehensive Sampling and Analysis Plan (CSAP) portion of the Resource Recovery and Conservation Act (RCRA) Facility Investigation (RFI) Work Plan. This document outlines all monitoring procedures to be performed during the investigation to characterize the environmental setting, source, and releases of hazardous constituents. In addition, the CSAP includes the Quality Assurance Plan (QAP) and Data Management Plan (DMP) to ensure that all information and data are valid and properly documented. Unless otherwise noted, the sampling strategy and procedures will be performed in accordance with the United States Environmental Protection Agency (USEPA) Environmental Services Division *Standard Operating Procedures and Quality Assurance Manual*, February 1, 1991 (ESDSOPQAM), included in Volume V of the RFI Work Plan. A copy of the ESDSOPQAM will be kept onsite to supplement the CSAP during all field operations. Sample analyses will be conducted in accordance with the guidance in USEPA *Test Methods for Evaluating Solid Waste, SW-846, 3rd ed.*, Office of Solid Waste and Emergency Response (SW-846) and in the USEPA Environmental Services Division *Laboratory Operations and Quality Control Manual* (ESDLOPQCM) (included in Volume V of this RFI Work Plan).

Due to the number and diversity of Solid Waste Management Units (SWMUs) and Areas of Concern (AOC) to be investigated at Naval Base Charleston (NAVBASE), the CSAP does not address site specific sampling strategies. Instead, this information will be presented in a series of zone-specific Sampling and Analysis Plans (SAPs) to be used in conjunction with the CSAP. Each zone-specific SAP will document any deviations from the CSAP. The zone based investigative rationale is described in greater detail in the Project Management Plan (PMP). The intent of this approach is to develop a work plan that is independent of the number of investigation sites, and therefore will not require iterative revisions as new sites are discovered.

The investigations will consist of various activities depending upon the nature of the subject site and the work previously completed by Navy contractors. Tasks will likely include but may not be limited to physical surveys, field sampling, and laboratory analysis. The physical surveys are screening tools and may consist of a preliminary air survey, habitat/biota survey, soil gas survey, aerial photograph reconnaissance, a contaminant source survey and Dexsil™ Cl^- or immunoassay screening. At a minimum, physical surveys will be conducted at USEPA Data Quality Objective (DQO) Level II protocol. The field sampling will be used to delineate the extent, nature, and/or magnitude of contamination in the selected media. Media to be sampled and analyzed includes surface water, sediment, soil, groundwater, and biota. The laboratories to be used are Naval Energy and Environmental Support Activity (NEESA)-approved and the QAPs of potential contract laboratories are included in Volume V of the RFI Work Plan for USEPA approval. Sample analysis and data collection efforts will satisfy USEPA DQO Level III protocol. A minimum of 5 percent of the samples will be analyzed at USEPA DQO Level IV for confirmation purposes. Any laboratory screening procedures will be performed at USEPA DQO Level II.

A report will be submitted to the Navy, USEPA, and South Carolina Department of Health and Environmental Control (SCDHEC) upon completion of the investigative work within each zone. The report will include laboratory analyses, a summary of the field activities, and the results and conclusions of the investigations. The results will provide a basis for a human health risk assessment and/or an ecological risk assessment to be completed at the subject sites. Information contained within the zone specific RFI reports will be summarized in a final report submittal that addresses NAVBASE as a whole.

1.1 Topography

NAVBASE is in the lower South Carolina Coastal Plain Physiographic Province, on the Cooper River side of the Charleston Peninsula. The Charleston Peninsula is formed by the confluence of the Cooper and Ashley Rivers. Topography in the area is typical of the South Carolina lower coastal plain, having low relief plains broken only by the meandering courses of sluggish streams and rivers which flow toward the coast past occasional marine terrace escarpments. Topography at NAVBASE is essentially flat. Elevations range from just over 20 feet above mean sea level (msl) in the northwest part of the base to sea level at the Cooper River. Most of the original topography at NAVBASE has been modified by man's activities. The southern end was originally tidal marsh drained by Shipyard Creek and its tributaries, and originally, the other portions of the facility were only slightly higher in elevation. The land surface at NAVBASE has been filled with both solid wastes and dredged spoil (primarily the latter) in increments over the last 93 years. Nonetheless, most of NAVBASE remains within the 100-year flood zone, that is, less than ten feet above msl.

1.2 Geology

Geology of the Charleston area is typical of the southern Atlantic Coastal Plain. Cretaceous and younger sediments thicken seaward and are underlain by older igneous and metamorphic basement rock (Figure 1-1). Surface exposures at NAVBASE, in the limited areas which remain undisturbed, consist of recent and/or Pleistocene sands, silts, and clays of high organic content. NAVBASE is underlain by a plastic calcareous clay known as the Cooper Marl. The Cooper Marl is, in turn, underlain by the Santee limestone and sequentially older rocks.

1.3 Soil Characteristics

Surface soils at NAVBASE have been extensively disturbed. Native soils were the fine-grained silts, silty sands, and clay, typical of terrigenous tidal marsh environments. Sand lenses are present in localized areas; however, these are generally only several feet thick. Much of the material, particularly in the southern portion of the base, has been filled using dredged spoil from the Cooper River and Shipyard Creek. The spoils are an unsorted mixture of sands, silts, and clays. Most of the remainder of the base has been either filled or reworked.

1.4 Surface Hydrology

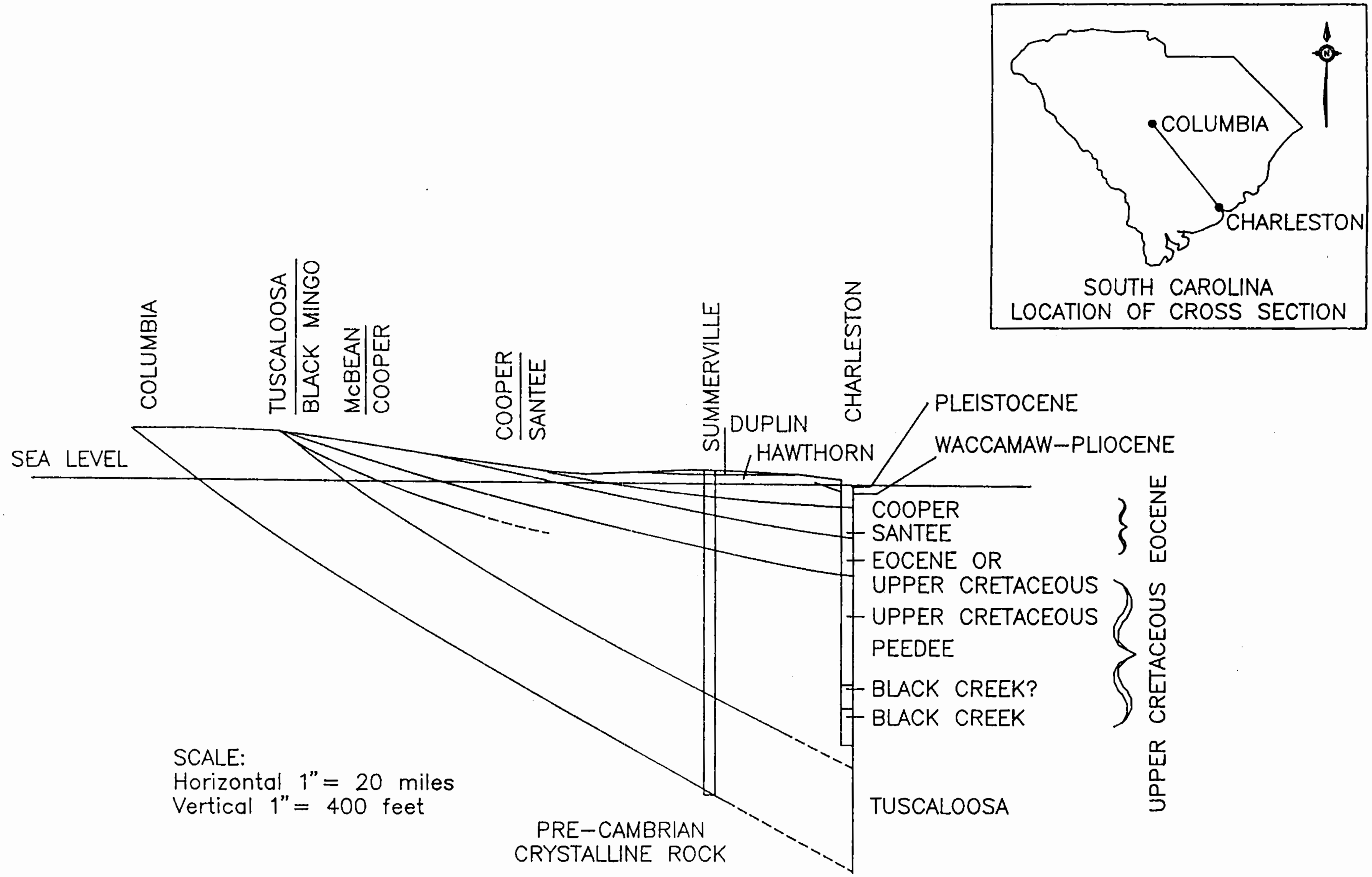
Parts of the southern portion of NAVBASE are drained by Shipyard Creek while some northern areas are drained by Noisette Creek. Both creeks are tributary to the Cooper River. Surface drainage over the remainder of NAVBASE flows directly into the Cooper River. The Cooper discharges into Charleston Harbor.

Shipyard Creek is a small tidal tributary, about two miles in length, which flows to the southeast along the southwestern boundary of NAVBASE to its confluence with the Cooper River, opposite the southern tip of Daniel Island. Docking facilities are located along the western shore of the lower mile of the channel, while the entire length of the eastern shore is bounded by tidal marshland.

Noisette Creek, which transects the northern portion of NAVBASE, is a tidal tributary approximately 2.5 miles long. The creek flows nearly due east from its headwaters in the City of North Charleston and empties into the Cooper River.

1.5 Hydrogeology

Two distinct aquifers exist beneath the NAVBASE site, a deep confined aquifer located within the Santee Limestone, and a shallow water table aquifer located within the near surface sediments. Both the shallow aquifer and the Santee Limestone function as potable aquifers in other locations. The shallow aquifer is not significantly developed in the NAVBASE area and is not developed at all at NAVBASE. A survey of groundwater users within a 7-mile radius of the NAVBASE was provided by the South Carolina Water Resources Commission to ascertain the extent, if any, of shallow groundwater usage in the vicinity of the NAVBASE. The survey indicated there are no wells screened in the surficial aquifer being utilized as a source for drinking water within a 4-mile radius of the NAVBASE. Currently, there is no evidence of groundwater being used as a potable water source at NAVBASE, apparently due to total dissolved solids (TDS) concentrations ranging from 1,000 to 1,500 parts per million (ppm) in the Santee. Even so, as outlined by the *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy*, Final Draft, December 1986, the shallow groundwater is classified as Class IIB, Potential Source of Drinking Water. In addition, the groundwater



SOURCE: NAVFAC, 1976 & ESE, 1981.

FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1–1
GEOLOGIC CROSS SECTION
FROM COLUMBIA TO CHARLESTON

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relating to the site has been classified as an underground source of drinking water (Class GB) by SCDHEC (*Water Classifications and Standards*, R.61-68).

The Cooper Marl, in the Charleston area, is a well documented confining layer for the Santee Limestone. The top of the Santee Limestone, which occurs at about 250 feet below msl in the NAVBASE area, has a groundwater potentiometric elevation of approximately 15 feet above msl. The hydraulic gradient is generally towards the southeast. Some wells in the vicinity of NAVBASE are pumping from the Santee for industrial purposes. In July 1981, the water level of a deep water well in the Santee Limestone beneath NAVBASE measured 15 feet below msl, indicating that the gradient across the confining Cooper Marl is artesian. Specifically, water from the confined aquifer of the Santee Limestone formation has an upward potential through the Cooper Marl.

Groundwater in the shallow aquifer beneath NAVBASE flows north-northeast into the Cooper River and south-southeast into Shipyard Creek due to the gently sloping topography away from the center of NAVBASE. Groundwaters in the immediate vicinity of Noisette Creek flow into it. The water table is within 3 to 7 feet of the ground surface. The shallow groundwater table continually but slowly discharges to the Cooper River and Shipyard Creek and, to a lesser extent, into Noisette Creek.

1.6 Climatology

The climate of the Charleston Harbor area is relatively mild compared to other areas further inland. The mountains if the northern portion of the state serve as a barrier to cold air masses from the northwest, and the Bermuda high pressure system limits the progress of cold fronts into the area. These conditions produce relatively mild temperate winters. Summers are hot and humid, but relatively moderate with regard to temperature extremes, largely due to the influence on the Gulf Stream (S. C. SEA Grant Consortium, 1992).

1.6.1 Temperatures

The average monthly air temperatures for the Charleston area are presented in Table 1.1. The temperatures are generally moderated by marine influences and are often 2-3 °C lower in the summer and 3-8 °C higher in the winter than those areas further inland from the harbor. Temperatures higher than 38 °C. and lower than -6.5 °C. are unusual for the area (S. C. SEA Grant Consortium, 1992).

1.6.2 Winds

The wind direction and velocity in the Charleston area are highly variable, and rather evenly distributed in all directions. The inland portions of the region are subjected to a southwest-northeast wind regime. The prevailing wends are northerly in the fall and winter, and southerly in spring and summer. The monthly average wind velocities and directions for the area range from a low of 12.1 kph in May to a high of 16.7 kph in March. The average monthly wind speeds and prevailing wind directions are presented in Table 1.1 (S. C. SEA Grant Consortium, 1992).

1.6.3 Rainfall

The Charleston area receives an annual average precipitation of 124.9 cm which is almost exclusively rainfall. Very little precipitation is recorded as snow, sleet, or hail. The greatest mean monthly precipitation is normally received in July while the smallest amount normally occurs in November (Table 1.2) (S. C. SEA Grant Consortium, 1992).

1.6.4 Humidity

Relative humidity in the Charleston Harbor area is normally very high and fluctuates greatly. Generally, it is higher during the summer months than other times of the year, and the coastal areas exhibit a lower relative humidity than inland portions of the area. The monthly mean relative humidity for four different times of day are presented in Table 1.2 (S. C. SEA Grant Consortium, 1992).

Table 1.1
Monthly and Annual Mean Temperature and Wind Data for Charleston Harbor between 1970 and 1985 (NOAA 1972, 1985)*

Month	Daily Max	Daily Min	Mean Speed km/hr	Prevailing Direction
January	16.4	3.1	14.8	SW
February	16.8	4.5	16.6	NNE
March	20.0	7.3	16.7	SSW
April	24.9	11.5	16.1	SSW
May	28.8	16.6	14.3	S
June	31.6	20.6	13.7	S
July	31.6	22.2	13.0	SW
August	31.5	21.4	12.1	SW
September	29.2	18.8	13.0	NNE
October	25.1	12.7	13.2	NNE
November	19.9	6.6	13.2	N
December	16.1	3.5	14.0	NNE
Annual	24.3	12.4	14.2	NNE

1.6.5 Cloud Cover

Cloud cover varies widely for Charleston, with annual averages of 101 clear days, 115 partly cloudy days, and 149 cloudy days. The mean monthly clear, partly cloudy, and cloudy days for the area are presented in Table 1.2 (S. C. SEA Grant Consortium, 1992).

1.6.6 Climate Extremes

The primary concern as far as climate extremes are concerned is the occurrence of tropical cyclones or hurricanes. Hurricanes frequent the east coast of the United States, and almost always have some effect on the weather around Charleston Harbor. Hurricanes normally occur between August and December. The last hurricane to make landfall in the Charleston area was hurricane Hugo a class IV hurricane which struck Charleston in September 1989 causing sever

Table 1.2
Table II-3. Monthly and Annual Mean Precipitation, Relative Humidity, and Cloud Cover for Charleston Harbor between 1960 and 1985 (Based on NOAA 1972, 1985).*

Month	Precipitation (cm)	Relative Humidity by Time				Cloud Cover % Number of Days		
		0100	*0700*	*1300*	*1900*	*Clear*	*Partly*	*Cloudy*
January	6.45	82	84	55	73	8	8	15
February	8.36	79	82	52	68	9	6	13
March	9.98	81	83	50	67	9	9	13
April	7.32	84	84	50	67	11	8	11
May	9.17	88	84	54	72	8	12	11
June	12.65	90	86	59	75	6	12	12
July	19.58	91	88	64	79	4	13	14
August	16.79	92	91	63	80	5	14	12
September	14.81	91	91	63	82	7	11	12
October	7.21	88	89	56	80	12	8	11
November	5.31	85	87	51	77	13	6	11
December	7.24	82	84	54	74	9	8	14
Annual	124.87	86	86	56	75	101	115	149

Note:
* (S.C. SEA Grant Consortium, 1992)

damage. Tornados are extremely rare in the vicinity but have occurred in the inland portions of Charleston county (S. C. SEA Grant Consortium, 1992).

1.7 Ecological Setting

A survey of available documents regarding natural resources was conducted at NAVBASE. The survey was conducted in order to make a preliminary identification of local flora and fauna, and any potential biological receptors such as sensitive environments. The following sections addresses the communities and sensitive environments identified during the survey.

1.7.1 Sensitive Environments

A tributary of the lower Cooper River, Shipyard Creek, forms part of the eastern property boundary of NAVBASE. Shipyard Creek is a navigable water body maintained to an Army Corps of Engineers authorized depth of 38 feet below mean low water. The periodic dredging of sediment in this river affects communities of benthic organisms. The river contains numerous wetlands including estuarine intertidal emergent, estuarine intertidal unconsolidated shore, and estuarine subtidal unconsolidated bottom. A significant wetland community exists in the intertidal emergent zone along Shipyard Creek. Vegetation consists primarily of *Spartina* spp. "Demersal fish species which are typically associated with the lower water column and substrate of Charleston Harbor include star drum (*Stellifer lanceolatus*), croaker (*Micropogon undulatus*), bay anchovy (*Anchoa mitchilli*), Atlantic menhaden (*Brevoortia tyrannus*), spotted hake (*Urophycis requis*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), blueback herring (*Alosa aestivalis*), white catfish (*Ictalurus catus*), and silver perch (*Bairdiella chrysura*). Other fish species commonly found in Charleston Harbor of primary interest to recreational and commercial fisherman include flounder (*Paralichthys spp.*), redfish (*Sciaenops ocellata*), spotted seatrout (*Cynoscion nebulosus*), bluefish (*Pomatomus saltatrix*), black drum (*Pogonias cromis*), and striped mullet (*Mugil cephalus*). Four anadromous fish species including shad and herring (*Aolsa* spp.), and striped bass (*Morone saxatilis*) and one catadromous species, American eel (*Anquilla rostrata*) also utilize Charleston Harbor and its tributaries as migration routes and spawning areas. Additionally, the endangered shortnose sturgeon (*Acipenser brevirostrum*), has been documented as occurring within Charleston Harbor (Eudaly et al, 1991).

A second tributary to the lower Cooper River, Noisette Creek, transects the northern portion of NAVBASE. Little information regarding Noisette Creek's physical attributes, such as mean depth, was discovered during this preliminary survey. The biota of Noisette Creek is anticipated to be similar to that of Shipyard River due to the propinquity of these bodies, with the exception of benthics as Noisette Creek is not dredged.

The Clouter Creek Dredge Area is located on the eastern shore of the Cooper River. Clouter Creek branches and rejoins the Cooper River to form an island reserved by the U.S. Navy for dredge disposal. A 1993 United States Geologic Survey (U.S.G.S.) Geology of the Cainhoy, Charleston, Fort Moultrie, and North Charleston Quadrangles, Charleston and Berkeley Counties, South Carolina map characterizes Clouter Creek Dredge Area as artificial fill surrounded by salt marsh. Extensive wetlands are indicated on the map including Broad Creek, which transects the island. The biota of this site is anticipated to be similar to biota of analogous wetland locations in the area. This may include nesting sites for migratory and resident wading and shore birds.

The majority of NAVBASE is characterized as disturbed material. primarily dredge spoil used for fill and material used in the upkeep of NAVBASE such as run of crusher (ROC) gravel, asphalt and concrete parking areas, buildings, laydown yards, and improved roads.

The wetland at the southwestern section of the Base is identified on Survey of Charleston Naval Base, Drawing h696-268, Map of Charleston Naval Shipyard, Naval Station, and Contiguous Activities Existing and Planned — as Modified by U.S. Army Corps of Engineers, Charleston District 2. February 1988. In summary, they include estuarine subtidal unconsolidated bottom and estuarine intertidal emergent zones along Shipyard Creek. An unimproved road transects the wetland inland from these zones and to the east of the road is primarily salt marsh with irregular topography which allows for zones in which non-hydrophytic vegetation exists. No other significant wetlands are known to exist at NAVBASE.

1.7.2 Threatened and Endangered Species

Information concerning threatened and endangered species was obtained from the South Carolina Heritage Trust of the South Carolina Wildlife and Marine Resources Department. Table 1.3 identifies species of concern listed for Charleston County and reports the status of these species.

Table 1.3
Endangered and Threatened Species in Charleston County, South Carolina

SPECIES NAME	COMMON NAME	STATUS
Flora		
Amaranthus pumilus	Sea-beach amaranth	T
Oxypolis canbyi	Canby's dropwort	E
Lindera melissifolia	Pondberry	E
Schwalbea americana	Chaff-seed	E
Myotis austroriparius	Southeastern myotis	C2
Agrimonia incisa	Incised groovebur	C2
Asplenium heteroresiliens	Wagner's spleenwort	C2
Aster georigianus	Georgia aster	C2
Dionaea muscipula	Venus' fly-trap	C2
Ilex amelanchier	Sarvis holly	C2
Litsea aestivalis	Pondspice	C2
Lobelia boykinii	Boykin's lobelia	C2
Pteroglossaspis ecristata	Eulophia	C2
Fauna		
Trichechus manatus	West Indian manatee	E
Falco peregrinus tundrius	Arctic peregrine falcon	T
Haliaeetus leucocephalus	Bald eagle	E
Vermivora bachmanii	Bachman's warbler	E
Mycteria americana	Wood stork	E
Picoides borealis	Red-cockaded woodpecker	E
Charadrius melodus	Piping plover	T
Lepidochelys kempii	Kemp's ridley sea turtle	E
Dermochelys coriacea	Leatherback sea turtle	T
Caretta caretta	Loggerhead sea turtle	T
Chelonia mydas	Green sea turtle	T

Table 1.3
Endangered and Threatened Species
in Charleston County, South Carolina

SPECIES NAME	COMMON NAME	STATUS
Fauna (continued)		
Acipenser brevirostrum	Shortnose sturgeon	E*
Odocoileus virginianus	Bull's Island white-tailed dear	C2
Plecotus rafinesquii	Fafinesque's big-eared bat	C2
Aimophila aestivalis	Bachman's sparrow	C2
Lateralus jamaicensis	Black rail	C2
Lanius ludovicianus	Loggerhead shrike	C2
Ophisaurus compressus	Island glass lizard	C2
Rana areolata capito	Gopher frog	C2
Ambystoma cingulatum	Flatwoods salamander	C2

2.0 GENERAL REQUIREMENTS

2.1 Sampling Strategy

Before any sampling is conducted, a sampling strategy will be developed. The sampling strategy will take into consideration:

- The environmental quality of the Base as a whole.
- The possible impacts of one SWMU/AOC on another.
- The benefit to be gained at one SWMU/AOC by sampling at another.
- The possibility of environmental contamination migrating onto an/or off of the Base.
- Specific data needs for various potential presumptive remedies; this is needed to know how to design the Corrective Measures Study (CMS), and when to end the RFI and begin the CMS.
- Data needs of other related activities such as the Baseline Risk Assessment.
- The specific need for each piece of data, and.
- A minimum of mobilizations.

2.2 Orientation Meeting

Before performing any field activities at the NAVBASE, sampling personnel will attend an orientation meeting summarizing general and site-specific requirements for sampling and documentation at NAVBASE. General topics to be discussed will include the base location, the locations of the site office trailer, subject site, decontamination area within the base; and the Comprehensive Health and Safety Plan (CHASP). Sampling requirements to be discussed will include general sampling protocol, the Unified Soil Classification System (USCS), use of the stainless-steel sampling sleeves if applicable, the sample numbering system, quality assurance/quality control (QA/QC) sampling requirements, and sample packaging. Documentation requirements to be discussed will include the use of field forms, field logbooks, and documentation of photographs. A checklist of requirements and an acceptance form indicating the above items have been reviewed by sampling personnel are provided in Appendix A.

2.3 General Sampling Requirements

General procedures for field personnel to follow when collecting environmental samples are included in this section. Detailed sampling procedures are discussed in Sections 4, 6, 7, 8, and 9. These general procedures are designed to prevent cross-contamination of samples.

General Sampling Procedures:

- Field sampling teams will have at least two people. One person will collect the sample as the other ensures adherence to the sampling procedures, records any difficulties encountered, and documents other information pertinent to the investigation. When sampling using the peristaltic pump/vacuum jug technique (often the preferred method for shallow wells where turbidity is of concern), the recommended order of collection is metals, cyanide, pesticides/PCBs, volatiles.
- All sampling activities in each medium will proceed from the area of least contamination to greatest contamination, if possible. If free product or contaminant-saturated media are encountered, collect grab samples there.
- The preferred order of sample collection in all media will be as follows (on a parameter basis): volatile organic analysis (VOA), total organic carbon (TOC), semivolatile organic analysis (SVOA), pesticides, herbicides, polychlorinated biphenyls (PCB), total metals, dissolved metals, cyanide, inorganics, and turbidity.
- The sampler will don a clean pair of protective gloves before collecting each sample.
- Samples for chemical analysis will be collected with either disposable sampling devices or decontaminated, stainless-steel or Teflon™ devices. When composite samples are required, they will be homogenized in stainless-steel bowls. All sampling equipment will be decontaminated in accordance with the procedures outlined in Section 15 of this plan.
- Disposable sample equipment will be constructed of Teflon™. The device will be decontaminated by the manufacturer before shipment to the site. An equipment rinsate blank will be collected before use.

- Fill all sample bottles, except for VOA bottles, to the shoulder to compensate for temperature and pressure changes during transport. If the container is filled below the shoulder, mark the level with a permanent marker or grease pencil. VOA bottles will be filled until there is zero headspace.
- Samples collected for VOA analysis will not be homogenized.
- All samples requiring chemical preservation shall be preserved immediately after field collection or the bottles may be preserved before sample collection.
- After collection, samples exhibiting obvious visual or olfactory contamination will be separated from the samples not exhibiting such evidence of contamination.
- Precleaned sample containers will be provided by the analytical laboratory except for the stainless-steel sleeves used for soil sampling, which will be decontaminated onsite. All data relative to sample container integrity shall be documented in the site log.
- Heterotrophic plate count samples will be collected with sterile containers and scoops provided by the laboratory.

Sample Processing:

Some of the analyses to be performed on selected samples require them to be preserved immediately after collection to maintain their integrity, as per the following procedures:

- Clearly identify the chemical preservative on the sample label.
- Chill all samples to 4 degrees centigrade (°C) immediately after collection and during shipment to the laboratory. In each cooler, include a 40-milliliter (ml) vial of tap water as a temperature blank or place a temperature strip on a sample bottle to measure its temperature at the time of receipt. If possible, samples from different sites will not be placed in the same cooler.
- Handle the samples as infrequently as possible. Use extreme care to ensure samples are not cross-contaminated. Use sealable plastic bags to protect samples from cross-contamination.

- A trip blank, prepared by the laboratory, will be shipped with each set of samples to be analyzed for VOA. It is not necessary to refrigerate trip blanks before use; store in a dust-free, organic-free environment away from fuels, solvents, and volatile compounds. Discard any trip blanks with bubbles larger than a pinhead.
- Avoid headspace (bubbles) in all VOA samples. VOA samples effervescing due to dissolved gases or high carbonate content will not be preserved with hydrochloric acid (HCl). Document unpreserved VOA samples on the chain-of-custody form and notify the laboratory before shipment.
- Identify and fully document all samples in the field logbook, on the chain-of-custody forms, and on the sample labels. Refer to the specific instructions for completing sample labels and chain-of-custody forms in Sections 11.3, 11.4, and 11.5 of this plan. Document all samples in accordance with the DMP.
- Follow chain-of-custody procedures to assure sample custody is maintained in a reliable manner and to assure each step in transportation to the laboratory is documented. This process will be initiated in the field and followed throughout the sampling process. Document chain-of-custody in accordance with the procedures described in Section 11.5 of this plan.
- Every effort will be made to ship all samples overnight to the laboratory on the day of collection via express air courier. Refer to Section 11.3 for sample shipment procedures. Record airbill numbers on the chain-of-custody forms.
- The laboratory will be notified in advance of sample shipment.

3.0 PHYSICAL SURVEYS

3.1 Well Inventory

Before beginning any field activities, all existing monitoring wells at the NAVBASE will be inventoried to ensure the validity and accessibility of groundwater sampling locations. A well integrity checklist is provided in Figure 3-1.

Before the Well Inventory

Before beginning the well inventory, the following information will be recorded on the well integrity checklist from previous reports.

- Well number and SCDHEC well permit number
- Reported dimensions of the monitoring wells including:
  - Diameter
  - Total well depth
  - Last available depth to water
  - Screened interval
  - Suspected contaminant

A site map will be included with the well inventory checklist for locating the monitoring wells.

During the Well Inventory

The condition of all monitoring wells will be checked and recorded on the well integrity checklist. Conditions to be checked will include:

- Legible labeling of the monitoring well (if the labeling is illegible, the wells will be relabeled during the inventory).
- Presence of a protective casing and the presence of weep holes.
- Presence of yellow bumper posts.
- Condition of the cement surface seal.
- Presence of a well cap and lock. (Damaged locks will be replaced during the well inventory.) All Installation Restoration Program (IRP)-related locks will be keyed alike.

Presence of odor or ionizable organic vapors using an photoionization detector (PID) or flame ionization detector (FID).

- Construction of the well including:
  - Construction material
  - Diameter
  - Depth to water and depth to bottom.

After the Well Inventory

Monitoring wells no longer needed will also be abandoned. All damaged wells (unable to be sampled) will be abandoned in accordance with SCDHEC standards and regulations. If additional monitoring wells are needed to replace the abandoned ones, they will be installed during the site-specific investigation. Damaged surface seals will be removed and replaced, bumper posts will be installed and/or painted, and protective casings will be repaired or replaced as necessary during the site-specific investigation.

3.2 Geophysical Surveys

3.2.1 Magnetometer Survey

A magnetometer survey identifies areas of buried metallic objects and geologic anomalies (magnetic mineral formations) contrasting with the surrounding rock or subsurface soil. The magnetic field strength, measured by the detector as a magnetic signal intensity, varies between $1/r$ and $1/r^3$ (r being the distance from the sensor to the buried object), depending upon the type of object. Metal location and depth of burial is indicated by the shape and width of the anomaly. The accuracy of this method is within 40 percent of the interpreted value. Total field and vertical gradient measurements are two types of magnetic surveys. Setup procedures apply to both types.

Figure 3-1 Well Integrity Checklist

WELL INTEGRITY CHECKLIST

Project: Naval Base Charleston

Field Personnel:

Date:

						Reported Dimensions				Field-Observed Dimensions			Calculation			
Well & Permit #	Location/ found/sketch	Protector/ Weep hole	Cement Surface Seal	Cap/ Lock	PID/FID Response or Odor (ppm)	Reported Diam. (inches)	Const. Depth (feet)	Last Avail. W.L. (feet)	Screened Depth (feet)	Obsv. Diam. (inches)	Obsv. W.L./ Time (feet)	Obsv. Depth (feet)	[Depth]- [W.L.] Depth (feet)	Column of Water (gallons)	Contam. Expect	Comments

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Setup Procedures:

1. Review past disposal practices to identify target and non-target areas.
2. Determine the minimum size of target to be identified.
3. Reconnoiter the site to identify areas of potential magnetic interference (e.g., metal fences, metal buildings, and power lines).
4. Review the site geology to determine if any geologic anomalies might interfere with target detection.
5. If anomalies are expected, estimate their intensity.

Establishing a Grid System:

6. A South Carolina-registered surveyor or EnSafe/Allen & Hoshall (E/A&H) personnel will define the two baselines (x and y axes) and record the baselines and other key elements of the grid on report maps. If possible, establish the grid so the lines are perpendicular to the target axes. If not possible, align the grid north to south or anchor it to a permanent site feature.
7. The baselines will be flagged at regular intervals, in accordance with the site-specific SAP. The distance between sampling points depends on the resolution required for a particular site. The closer the sampling points are to each other, the greater the resolution.
8. The internal grid points then will be established using a Brunton compass and measuring tape. Use a non-metallic marker, such as a wooden stake, to identify stations.
9. Check the calibration date of the magnetometer. If the magnetometer has been calibrated more than one year ago, return it for recalibration.

Total Field Measurement Survey

The total field measurement is a scalar measurement of the total magnetic field intensity. The person operating the magnetometer must be free of any magnetic material (e.g., steel-toe boots).

Survey Procedures:

1. Place the magnetometer at a station, properly orient the sensors, and collect the reading in accordance with the manufacturer's operating manual.
2. Hold the magnetometer approximately 0.5 meters above the ground surface to obtain a reading. At subsequent grid nodes, the magnetometer must be held at the same height. A 0.5-meter mark on a staff may be used to estimate this height.
3. Record the magnetometer reading, measurement time, grid node identification, and applicable comments in the field logbook.

Vertical-Gradient Field Measurements

The vertical gradient field measurement consists of two or more total field measurements taken at different sensor heights. This helps quantify regionally pervasive magnetic effects from nearby building or ubiquitous bedrock magnetization.

Survey Procedures:

1. At each grid node, collect total field measurement at 0.5 meters above the ground surface.
2. Collect a second reading with the sensor approximately 1 to 2 meters above the point where the first reading was taken. A staff will be designed to hold the two sensors so separation can remain constant.
3. Record the second value and the distance between the readings.
4. Record any additional comments in the field logbook.
5. Collect readings at the remaining grid nodes with the same distance between the first and second readings.

In most cases it will be necessary to correct for drift and sudden fluctuation in the earth's magnetic field intensity. This can be done in one of two ways. Method 1 uses a "tie base station" and repeats the measurements there at least once every hour. The data obtained between repeats at the base station can then be corrected by a linear interpolation. Method 2 uses a second magnetometer to continuously monitor the magnetic field. The data are then corrected manually or by software in digital magnetometers. Method 2 is more costly but more accurate, and is sometimes necessary due to prevailing conditions.

3.2.2 Electromagnetic Induction Survey

This section describes the procedures for conducting an electromagnetic (EM) survey with an EM-31 terrain conductivity meter. Survey procedures are detailed below.

Induction Survey Setup Procedures:

1. Review past disposal practices at the site in order to identify buried targeted and non-targeted metallic objects.
2. Review the site geology for variable geologic conditions or features, possibly causing spurious anomalies affecting target detection.
3. If anomalies are expected, estimate their intensities.
4. The EM survey can be completed with horizontal and/or vertical dipoles, and with conductivity with/without in-phase component.
5. The intervals of the grid system will be defined in the site-specific SAP.
6. Tie the grid system to existing permanent features (i.e., roads and buildings) so the grid may be used for locating and mapping physical site features, such as monitoring wells, and tracing contaminant plumes.
7. Mark the grid system origin and key axes using a Brunton compass and tape to ensure accurate instrument placement.

EM Instrument Calibration

EM instruments are calibrated by the manufacturer. Instrument calibration checks will be performed before use each day in accordance with manufacturer's specifications.

If site activities are expected to last more than one day, select a local standard site in the field to provide a reference base station. The instrument will be calibrated daily at the base station to check for drift in the instrument's performance.

EM Instrument Field Check Procedures:

1. Select a reference base station without nearby conductors and obtain a reading with the EM instrument.
2. Record the site location, orientation of each coil (e.g., east-west versus north-south), coil spacing, and the EM reading in the field logbook.
3. At the beginning of each subsequent day, obtain a reading at the test site with the same coil spacing and orientation as before. Variation should be less than ±5 percent.
4. Record the reading and location in the field logbook, and compare with the initial reading to cross-check for instrument drift.

Data may be obtained using horizontal or vertical dipoles. For an EM-31, the horizontal dipoles are selected when the instrument is placed with the meter facing up; vertical dipoles are selected when the meter faces the horizon. In both cases, the long boom is held parallel to the ground at a fixed height. Horizontal dipoles are usually used since they provide the deepest penetration (about 12 meters). Vertical dipoles are only useful in certain applications (i.e., when better resolution at shallower depths is required.)

In addition, one can choose conductivity mode and/or in-phase mode. Always use at least conductivity mode. In-phase can be run in addition to conductivity to help better define buried metals.

3.3 Cadastral Survey/Geodetic Survey

When the field investigation is complete, a survey will be conducted to locate all sampling locations, both horizontally and vertically. The vertical elevations will be surveyed to an accuracy of ±0.01 foot. The horizontal locations will be supplied in latitude and longitude, in accordance with North American Datum (NAD) 83. In addition, locate all utilities, above-ground structures, and surface improvements (e.g., pavement). Geodetic surveys will be conducted using a differential global positioning system (GPS). The cadastral survey will be conducted by vendor-registered land surveyors in South Carolina.

4.0 SOIL SAMPLING

Soil sampling locations will be positioned in accordance with the site-specific SAP. Techniques for sample collection depend on the soil type and depth of the sample. Surface soil sampling will be conducted in accordance with Section 4.11 of the ESDSOPQAM found in Volume V of the RFI Work Plan. Surface samples are defined as 0 to 1 foot below land surface (bls) exclusive of rocks, twigs, leaves, and vegetation. Surface soil samples may be collected manually with hand augers. Power devices such as drill rigs or backhoes frequently are used for deeper subsurface samples, depending on the depth of the sample to be collected and the soil type. Samples collected with a drill rig may include steel split-barrel samplers with stainless-steel liners, steel split-barrel samplers without liners, or Shelby tubes (Shelby tubes will only be used to collect samples to be analyzed or tested for physical parameters). If stainless-steel liners are used, all samples (except for VOA) will be homogenized in the field.

Each soil sampling team will have at least two members. One person will collect the sample as the other documents information in the field logbook regarding adherence to sampling procedures, difficulties encountered, and other pertinent information.

4.1 Designating Soil Collection Locations

Soil boring, surface soil sample collection locations, and test trenches will be designated in compliance with the sample identification system outlined in Section 11.4 of this CSAP to facilitate sample data management. Soil borings, surface soil sample collection locations, and test trenches will be labeled by site (first three digits), media sampled (one matrix digit), and unique number (four digits). For example, if soil boring 28 was advanced at SWMU #36, the boring designation would be "036S0028." Another example: if a surface soil sample was collected at location 12 at SWMU 30, the designation should be "030S0012." Different identification numbers must be designated for surface soil collection locations and soil borings. For example, if a surface soil sample is to be collected at location 01 at SWMU 33 and a soil boring designated "01" also was advanced at SWMU 33, the identification numbers would be the same (033S0001). These errors are easily avoided with careful planning. Previously existing borings, surface sampling locations, and trench identifications will be modified to correlate with this labeling system. For example, the soil boring at location 04 of SWMU 9, currently labeled "S09-B04" would become "009S0004."

4.2 Soil Description

Samples will be described by a qualified geologist using the USCS on a soil boring log. A USCS summary and sample boring log are included as Figures 4-1 and 4-2, respectively. If trenching is used to uncover subsurface soil, soil characteristics should be described in the field logbook. Descriptions will include color, texture, grain size, staining, and odor. In accordance with the American Society for Testing and Materials (ASTM) standards for Description and Identification of Soils using the USCS (Visual-Manual Procedure) (ASTM D2488-90).

4.3 Soil Screening Techniques

4.3.1 Dexsil™ Cl^- Screening

Dexsil™ Cl^- screening is an effective tool for pesticide/PCB screening and is useful for establishing soil sampling locations. This survey requires establishing a grid system across the site. This may be done using the grid establishment procedures provided in Section 3.2. Soil samples may be collected from the designated intervals using any of the procedures provided in this section. Procedures for using the Dexsil™ equipment are provided below.

Before Sampling

1. Attach power supply.
2. Fill the electrode with filling solution provided by the manufacturer.
3. Empty the electrode by pressing down on the white cap.
4. Refill the electrode with the filling solution to the hole.
5. Fill one 40-ml VOA vial with rinse solution provided by the manufacturer.
6. Place the electrode in the rinse solution.

AGI DATA SHEET 38.1

Unified Soil Classification System

Compiled by B. W. Pipkin, University of Southern California

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS More than half of material is larger than no. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than no 4 sieve size.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction is smaller than no 4 sieve size.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS More than half of material is smaller than no. 200 sieve size.	SILTS AND CLAYS	Low liquid limit	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
		High liquid limit	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly organic soils			Pt	Peat and other highly organic silts.

NOTES:

1. Boundary Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U.S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus no. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (next page), and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. For a complete description of the Unified Soil Classification System, see "Technical Memorandum No. 3-357," prepared for Office, Chief of Engineers, by Waterways Equipment Station, Vicksburg, Mississippi, March 1953. (See also Data Sheet 29.)

SOURCE: AGI DATA SHEETS 3rd ed. 1989

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4-1
UNIFIED SOIL
CLASSIFICATION SYSTEM

DWG DATE: 08/08/94 | DWG NAME: BOARD

FIGURE 4-2 BORING LOG

NAVY CLEAN
ENSAFE/ALLEN & HOSHALL
(901) 383-9115

JOB NO.

CLIENT

LOCATION

DRILLING METHOD:

BORING NO.

SHEET OF

SAMPLING METHOD:

DRILLING

					START	FINISH
WATER LEVEL					TIME	TIME
TIME						
DATE					DATE	DATE
CASING DEPTH						

LOCATION OF BORING

DATUM

ELEVATION

SURFACE CONDITIONS:

SAMPLER TYPE	INCHES DRIVEN / INCHES RECOVERED	DEPTH OF CASING	SAMPLE NO. / SAMPLE DEPTH	BLOWS/FT SAMPLER	VAPOR CONCENTRATIONS (PPM)	DEPTH IN FEET	SOIL GRAPH
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	
						1	
						2	
						3	
						4	
						5	
						6	
						7	
						8	
						9	
						0	

DRILLING CONTR ______

BY ______ CHK BY ______

DATE ______

029CBORL

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Calibration

7. Turn power on.
8. Fill one 40-ml VOA vial with calibration solution.
9. Remove the electrode from the rinse solution and wipe with Kemwipe™.
10. Place electrode in calibration fluid and swirl for a few seconds.
11. Move selector knob to "CAL."
12. Press "Start."
13. When "READ" light comes on, adjust to "50."
14. Remove electrode from calibration solution, wipe with Kemwipe™, and place in rinse solution.

Sample Preparation

15. Tear a white-capped tube removing the cap provided by the manufacturer.
16. Weigh 10 grams of soil in tube.
17. Empty contents of one extract solution into tube.
18. Shake for one minute. Let settle for two minutes.
19. Setup drying tube/syringe apparatus. Place apparatus in black-capped tube.
20. Use polyethylene pipette to remove at least 7 ml of extraction solvent from top of soil. Place solvent in open syringe.
21. Apply pressure to syringe to force the solvent through drying column at a rate of two to three drops per second.
22. Fill black-capped tube to the 5-ml line. Replace black cap tightly.
23. Break the bottom clear ampule. Shake for 10 seconds.
24. Break the top gray ampule. Shake for 10 seconds. Continue to shake intermittently for 60 seconds.
25. Add 5 ml of extract solution (using 5-ml pipette). Shake for 10 seconds. Vent cap (turn 1/2 turn), squeeze tube, and cap tightly. Shake vigorously for 20 seconds.
26. Allow tube to settle upside down for two minutes.

27. Filter bottom phase through polyethylene filter funnel into analytical vial (small white vial). Stop filtering when first drop of yellow liquid hits the filter.
28. Allow extracted fluid to cool for five minutes.

Analysis

29. Remove electrode from rinse solution. Wipe dry with Kemwipe™.
30. Place electrode in extracted solution.
31. Press "start."
32. Read and record results.

After Analysis

33. Place all investigation-derived wastes (IDW) in 55-gallon drums for future disposal by the Navy in accordance with Section 16 of this CSAP.

4.3.2 Immunoassay Screening

Immunoassay screening is effective for petroleum hydrocarbon, polyaromatic hydrocarbons (PAH), pentachlorophenol (PCP), and PCB screening and is useful for establishing soil sampling locations. This survey may require establishing a grid system across the site using the procedures in Section 3.2. Soil samples may be collected from the designated intervals using procedures provided in this section. Procedures for using immunoassay screening equipment varies between manufacturers and are provided in each test kit. Procedures for use will be detailed in the site-specific SAP.

4.4 Surface Soil Sample Collection

Before Surface Soil Sampling:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled.
3. Clear vegetation and other debris from the surface around the boring location.

4. Place clean plastic sheeting on the surface near the sample collection location to hold decontaminated sampling equipment.
5. Set up a decontamination area for sampling equipment, if required.

During Surface Soil Sampling:

6. Remove surface debris from the sample location.
7. With a stainless-steel device, scrape the sample collection location to obtain a previously unexposed surface.
8. Use a decontaminated stainless-steel or Teflon™-lined sampling device (e.g., spoon, spatula) to collect the volume needed to fill the sample container(s).
9. For Grab samples:
    - Completely fill the sample containers directly from the sampling device, avoiding twigs, large rocks, and grass. Collect the VOA samples first.
    - Be sure to have zero headspace in the VOA sample container.
    - Place the remainder of the sample in the mixing bowl and thoroughly homogenize. Place the homogenized mixture into the appropriate sample containers.

    For Composite samples:
    - Empty contents of the sampling device into a decontaminated stainless-steel or Teflon™-lined bowl. Collect enough to fill all the containers.
    - Mix sample in accordance with ESDSOPQAM procedures using a decontaminated stainless-steel or Teflon™-lined spoon or spatula. *Do not mix samples for VOA analysis.*
    - Place the homogenized mixture into the appropriate sample containers.

    For Toxicity samples:
    - Empty contents of sampling device into appropriate sample container.
    - Toxicity samples will not be composited.
10. Secure container with Teflon™-lined cap.
11. Label each sample container and preserve to 4°C.

After Surface Soil Sampling:

12. Backfill the borehole with any excess soil.
13. Record pertinent information in the field logbook.
14. Clean site. Place contaminated disposable materials in the designated drum for disposal by the Navy.

4.5 Hand-Augering Sample Collection

Before Augering:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled. The survey will include horizontal location and elevation relative to msl or other specified reference data. Horizontal and vertical surveying may occur before or after the sampling event, as applicable.
3. Clear vegetation and other debris from the surface around the boring location.
4. Place clean plastic sheeting on the surface near the sample collection location to hold decontaminated sampling equipment.
5. Set up a decontamination area for sampling equipment, if required.

During Augering:

6. Begin augering to the depth required for sampling.
7. Make detailed notes about geologic features of the soil or sediments on a field boring log.
8. Stop drilling at the top of the specified or selected sampling depth. Remove the contaminated auger bucket and replace with a decontaminated bucket.
9. Collect sample.
   - Without homogenizing, collect VOA samples from auger bucket and immediately place into the appropriate container. Fill the container so there is zero headspace.

- Place the remaining sample volume into a stainless-steel bowl. Mix the sample in accordance with ESDSOPQAM procedures until thoroughly homogenized and place into the appropriate containers. Label the samples and preserve to 4° C.
- Record the sample identification number, sample collection depth, and analyses required in the field logbook and/or on the appropriate field forms.

10. Proceed with additional sampling, as the site-specific work plan requires.

After Augering:

11. Backfill the borehole with excess cuttings, neat cement grout, or hole plug as the site-specific work plan stipulates.
12. Decontaminate all equipment in accordance with Section 15 of this CSAP.
13. Place used plastic sheeting and other disposable sampling equipment in the designated drum for disposal by the Navy.
14. Complete the field logbook entry and soil boring log for the site.

4.6 Sample Collection by Drill Rig/Backhoe

Soil borings advanced by a drill rig will use hollow-stem augers as outlined in Appendix E.2.1 of the ESDSOPQAM. During borehole advancement, a PID or FID will be used to monitor the breathing zone for volatile organic vapors. The augers will be advanced without a center plug to facilitate split-barrel or Shelby tube sample collection. To improve recovery in sandy soil, continuous split-spoon sampling may be completed using a Central Mine Equipment continuous coring system in some areas. Soil boring locations will be determined based on the site-specific SAP. After soil samples are obtained to the proper depth, the borings will be abandoned with neat cement grout or completed with monitoring wells. Soil samples also may by collected from test trenches. Specific sampling procedures are provided below.

4.6.1 Split-Barrel

Before Split-Barrel Sampling:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled.
3. Clear vegetation and debris from the surface.
4. Prepare the site by placing plastic sheeting around the borehole and over the sampling table.
5. Align the derrick of the drill rig at the sampling location.
6. Set up a decontamination area for sampling equipment, if required.
7. Install four decontaminated, 6-inch, stainless-steel liners in the steel split-barrel sampler, if required.

During Sampling:

8. Install a decontaminated steel split-barrel sampler on the center rod(s) and insert into the hollow-stem auger. Connect the hammer assembly and lightly tap the rods to seat the drive shoe at the ground surface.
9. If blow counts are needed, mark the center rods in 6-inch increments from the top of the auger flight(s).
10. Drive the sampler using the hammer. Use a full 30-inch drop as specified by ASTM Method D-1586. Record the number of blows required to drive the sampler through each 6-inch increment.
11. If blow counts are not needed, push the sampler using the drill rig's hydraulics.
12. Cease driving or pushing when the full length of the sampler has been driven or upon sampler refusal. Refusal occurs when little (<1 inch) or no progress is made after 50 blows of the hammer.
13. Pull the sampler free by using upswings of the hammer to loosen it, or using the drill rig's winch. Pull out the center rod and sampler.
14. Unscrew the split-barrel assembly from the center rod and place it on the sampling table.

15. Remove the drive shoe and head assembly. If necessary, tap the split-barrel sampler assembly with a decontaminated hammer to loosen threaded couplings.

16. Processing for samples collected *with stainless-steel liners:*

    a. With the drive-shoe and head-assembly off, split the sampler and remove the liners without disturbing the contents.

    b. Screen sample with PID or FID, and select two samples with highest readings for laboratory analysis. If there are no headspace readings, submit the two bottom liners for laboratory analysis.

    c. Immediately install a Teflon™ septa over the ends of the selected liners and cap and seal the VOA samples with PVC caps. The remainder of the sample material will be placed in a stainless steel mixing bowl and thoroughly homogenized prior to containerization.

    d. If additional samples are needed for quality control (e.g., duplicates, matrix spike (MS) samples, matrix spike duplicate (MSD) samples) the other two liners will be covered and capped.

    NOTE: ***If the recovery is not complete (<2 feet), submit the two sleeves with the most complete recovery.***

    Processing for samples collected *without stainless-steel liners:*

    a. With the drive shoe and head assembly off, split the sampler and expose the contents.

    b. Screen sample with PID or FID.

    c. Immediately containerize samples for VOA analysis with zero headspace. Place the remaining sample into a stainless-steel bowl for mixing. After homogenizing in accordance with ESDSOPQAM procedures, containerize the sample.

17. Label the samples in accordance with Section 11 of this CSAP.

18. Preserve the samples at 4°C.

19. Decontaminate sampling equipment as needed in accordance with Section 15 of this CSAP.
20. Attach the hollow-stem auger with the cutting head and center rod(s).
21. Proceed to the next sampling depth.
22. Slightly raise the auger flight(s) to disengage the cutting head and rotate without advancement to clean cuttings from the bottom of the hole.
23. Collect samples as outlined above by inserting the steel split-barrel sampler into the hollow-stem auger.
24. Describe sample lithology on soil boring logs based on observations of the auger cuttings, the bottom end of the sample in the liner, or the sample inside the split-barrel sampler (when liners are not used).

After Split-Barrel Sampling:

25. Backfill the borehole with neat cement grout or hole plug as stipulated by the site-specific work plan stipulates.
26. Remove the drill rig to the heavy-equipment decontamination area.
27. Place used plastic sheeting and other disposable sampling equipment in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
28. Record all relevant information in the field logbook before leaving the site.

4.6.2 Shelby Tube

Before Shelby Tube Sampling:

1. Don personal protective clothing and equipment as required by the site-specific CHASP.
2. Stake the location(s) to be sampled.
3. Clear vegetation and debris from the ground surface.
4. Prepare the site by placing plastic around the borehole and over the sampling table.
5. Align the decontaminated drill rig to the sampling location.
6. Set up a decontamination area for sampling equipment if required.

During Sampling:

7. Advance augers to the desired sample depth.
8. Attach a head-assembly to a decontaminated Shelby tube. Attach the Shelby tube to the center rods.
9. Lower the Shelby tube and center rods into the hollow-stem augers until seated at the bottom.
10. Use the rig's hydraulics to push the Shelby tube to its full length or until refusal. Attach a hoisting plug to the upper end of the center rod, twist to break off the sample, and pull it out of the borehole with the rig winch.
11. Retrieve the Shelby tube to the surface, detach it from the center rod, and remove the head assembly.

    NOTE: Shelby tubes may not retain loose, sandy soil.
12. If the Shelby tube does not have a full recovery, pack the remaining space with paraffin to prevent soil movement within the tube.
13. Seal the ends of the Shelby tube immediately. Mark the top end of the tube for transport to the laboratory.

After Shelby Tube Sampling:

14. If drilling is complete, abandon the borehole with neat cement grout or hole plug as site-specific work plan stipulates.
15. Remove the drill rig for decontamination.
16. Place used plastic sheeting and any other disposable equipment in the appropriate drum for disposal by the Navy.
17. Record relevant information in the field logbook before leaving the site.

4.6.3 Test Trenching

Test pits and trenches are open excavations used to determine the shallow subsurface conditions at the site. Test pits and trenches can be excavated manually or mechanically with a backhoe or bulldozer.

Before Trenching:

1. Don personal protective equipment as the site-specific CHASP requires.
2. Collect surface soil samples if the site-specific work plan requires.

During Trenching:

3. Carefully excavate soil in 1-foot increments and stockpile in a designated area on plastic sheeting.
4. Collect subsurface soil samples as required in the site-specific work plan. Avoid entering the test trenches. Use sampling devices, such as a hand auger with extension handles/rods, to collect samples after removing smeared materials with a decontaminated spoon or other scraping device. If necessary, collect samples from the center of the decontaminated backhoe bucket from a previously unexposed surface. Conduct sampling in accordance with Sections 4.4 or 4.5 of this CSAP.
5. If the test trench is deeper than 3 feet and personnel entry is required, walls must be stabilized according to Occupational Safety and Health Administration (OSHA) requirements.
6. Water or other liquids removed from the excavation must be considered contaminated. Contain the liquid until it can be returned to the excavation properly disposed of by the Navy in accordance with Section 16 of this CSAP.

7. Sample liquids in a test trench according to surface water sampling procedures presented in Section 7 of this CSAP or sample using a decontaminated stainless-steel well screen and decontaminated bailer.
8. Photograph all significant features in the test trench. Record all pertinent information in the field logbook as listed in Section 4.2.

After Trenching:

9. As required, collect samples of the stockpiled soil for Toxicity Characteristic Leaching Procedure (TCLP) analyses.
10. Backfill the trench with clean material or stockpiled soil to the surface after all samples have been collected in accordance with the site-specific work plan.
11. Place all used plastic sheeting and other disposable equipment in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
12. If stockpiled soil is contaminated, dispose of it in accordance with applicable state and federal regulations.

5.0 INSTALLING AND DEVELOPING MONITORING WELLS

The following section provides procedures for installing temporary monitoring wells, installing permanent monitoring wells in unconfined and confined aquifers, and developing those wells. The installation of temporary wells (i.e., a well installed for a one-time sampling event) is not anticipated; however, the method is presented as a viable alternative to Hydropunch sampling for collecting screening level data for sample analyses that require greater than 500 ml of sample volume should it become necessary.

5.1 Monitoring Well Permitting

Before beginning drilling activities, a well permit must be obtained from SCDHEC for all monitoring well installations in accordance with the *South Carolina Well Standards and Regulations (R.61-71)*. Approval for the installation of all monitoring wells, including permanent, temporary and/or non-standard wells (Hydrocone™, Hydropunch™, etc.) will be obtained from the SCDHEC prior to installation. Specific items to be included in the request are listed below.

- Proposed monitoring well designation number.
- Site map showing proposed locations of the monitoring wells.
- Proposed monitoring well construction details including materials of construction, depth of monitoring well, and depth of screened interval.
- Proposed monitoring well construction procedures including hydration time for bentonite pellets and cure time for bentonite grout.
- Justification for installing flush-mount monitoring wells, as necessary, and a list of monitoring wells to be flush-mounted.

The request for monitoring well installation approval should be submitted at least three weeks before beginning drilling activities.

5.2 Monitoring Well Designations

Monitoring wells will be designated as part of the sample identification system to facilitate sample data management. Monitoring well designations, therefore, will comply with the sample identification system outlined in Section 11.4 of this CSAP. Monitoring wells will be designated according to SWMU (first three digits), media to be sampled (one matrix digit), and the unique well number (four digits). For example, if monitoring well 23 is installed at SWMU 47, the groundwater monitoring well designation would be "047G0023." Pre-existing wells will be designated by modifying the well name to correlate with this monitoring well designation system. For example, monitoring well XY-14 near SWMU 22 would become "022GXY14." Another example: a monitoring labeled S21-W14 (well number 14 at SWMU 21) would become "021G0014." A unique number must be assigned to all wells. The well inventory will be consulted before assigning a number to a new or existing monitoring well to prevent duplication.

5.3 Drilling Methods

For a *permanent* monitoring well, boreholes will generally be advanced using hollow-stem augers with PVC plugs, as outlined in Appendix E.2.1 of the ESDSOPQAM (included as Volume V of the RFI Work Plan), if no soil is to be sampled. The PVC plug may be needed to keep the augers clear while drilling in saturated media. If soil must be sampled, the borehole will be advanced and sampled in accordance with Section 4 of this CSAP. In flowing sand conditions, water will first be added to the augers to keep them clear of sand. If this fails, water rotary methods will be attempted. Mud rotary drilling techniques will be attempted only as a last resort. Pure bentonite drilling mud will be used in these instances.

For a *temporary* monitoring well, soil borings will be advanced using manual (hand) auger drilling methods or hollow-stem auger.

5.4 Monitoring Well Construction

All monitoring wells will be constructed in accordance with the SCDHEC regulations and as outlined in Appendix E.4.1 and E.4.2 of the ESDSOPQAM with the following modifications.

- A tremie pipe will be used to place well construction materials if the total depth of the borehole is 20 feet or greater.
- The PVC well construction materials will meet National Sanitation Foundation (NSF) Standard 14wc, in addition to ASTM Schedule 40. Refer to Figures 5-1 and 5-2, respectively, for typical monitoring well construction diagrams in unconfined and confined aquifers. Detailed monitoring well construction procedures are outlined below.
- If hollow-stem auger drilling methods are used, the auger will act as a tremie pipe during well installation.
- The grain size of the sand pack and monitoring well screen slot size will be determined by the results of one or more (more will be necessary when distinct changes in lithology are observed) grain size analyses conducted for each SWMU or zone. The procedure for determining the appropriate filter pack size in presented in Section 5.4.1 below.
- If the well casing arrives onsite with printing and/or writing on it, remove the printing with Emery cloth or sand paper before being cleaned. *No* solvents or hot water may be used to clean the PVC materials.
- After installing the monitoring well, notch the top of the inner casing. This point will be the reference mark for elevation measurement.
- All monitoring wells will be labeled with an identification plate constructed of a durable material affixed to the casing or surface pad where it is readily visible. The plate shall provide monitoring well identification number, date of construction, static water level, and driller name and state certification number.
- To reduce the cross-contamination risk, the outer protective casings of the monitoring wells will not be painted onsite. Monitoring well construction in an unconfined aquifer and a confined aquifer will be documented in the field logbook or on monitoring well

construction logs provided in Figures 5-3 and 5-4, respectively. Detailed monitoring well construction procedures are provided below.

5.4.1 Filter Pack Material and Screen Slot Size Design

The filter pack materials shall consist of well-rounded to rounded, clean, silica sand. Filter pack material of varying grain sizes will not be used. As a general rule, the material must have a uniformity coefficient of 2.5 or less.

When installing the first well in a given zone, a representative sample of the aquifer matrix from within screened interval (both shallow and deep wells) will be collected for grain size analysis using ASTM D-2434 or similar method. Grain size will continue to be analyzed at each well location within a given zone where the screened interval is within a previously uncharacterized lithology. To determine an appropriate filter pack size to limit the entrance of formation materials into the well and minimize head loss, the following procedures will be followed.

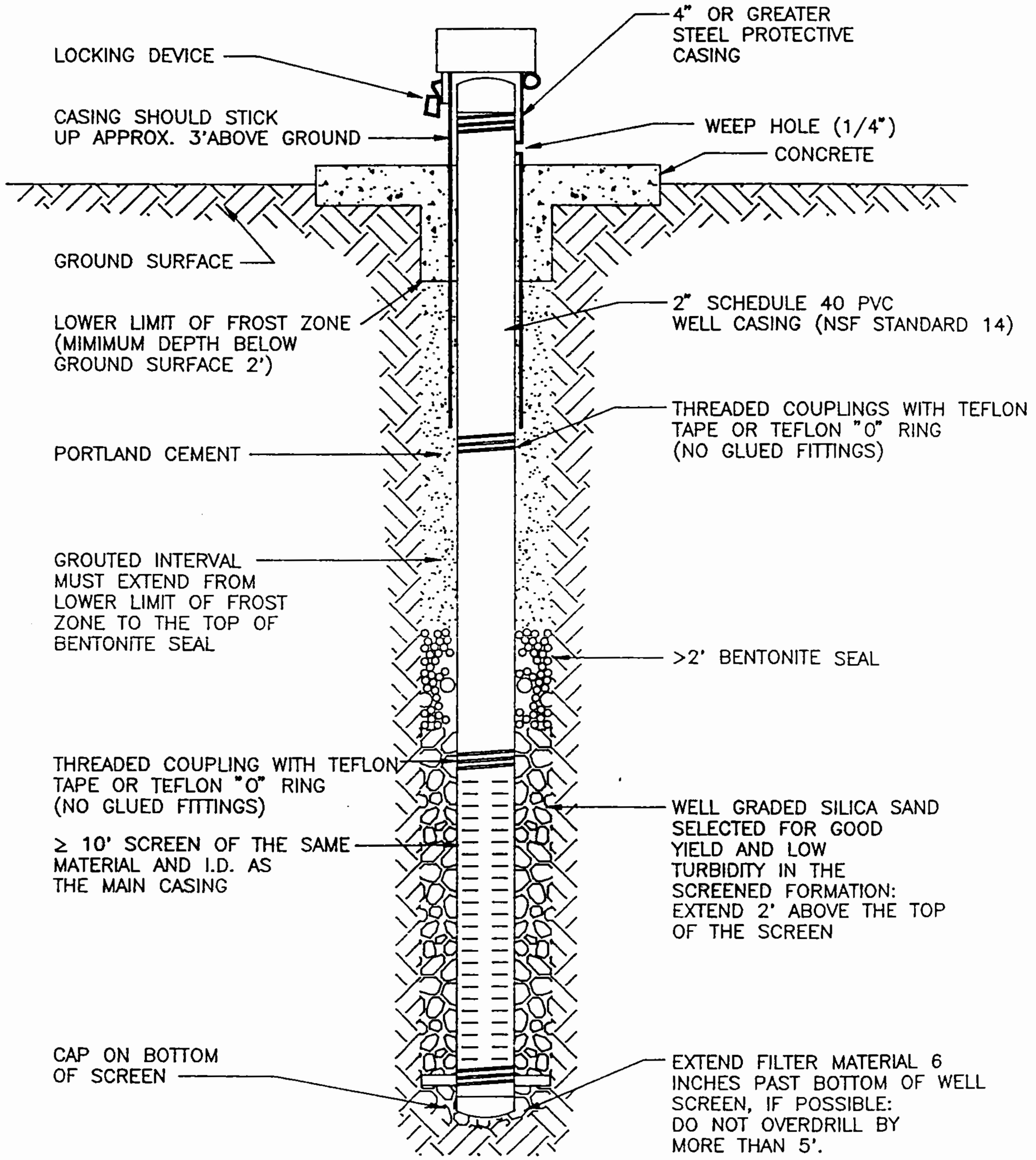
- A grain size distribution curve will be constructed on a grain size distribution graph using the results of a sieve analysis performed on the aquifer material;
- Multiply the D50 (50 percent passing) size by a factor of 2;
- Plot this point on the D30 (30 percent passing) abscissa of a grain size distribution graph and draw a smooth curve with uniformity coefficient of approximately 2.5. This represents the grain size distribution of an appropriate filter pack size.
- Select the slot size openings for a well screen that will retain a minimum of 90 percent of the filter pack material.

5.4.2 Monitoring Well Installation (Unconfined Aquifers)

Before Installation:

1. Make sure area is clear of all underground and overhead utilities using Public Works Department utility maps. Clear vegetation and debris from monitoring well site.
2. Place plastic sheeting on ground near the area to hold decontaminated equipment.

TYPICAL ILLUSTRATION OF MINIMUM SPECIFACTIONS
FOR MONITORING WELL CONSTRUCTION



FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 5-1
UNCONFINED AQUIFER
MONITORING WELL DESIGN

DWG DATE: 08/08/94 | DWG NAME: 029TYPE2

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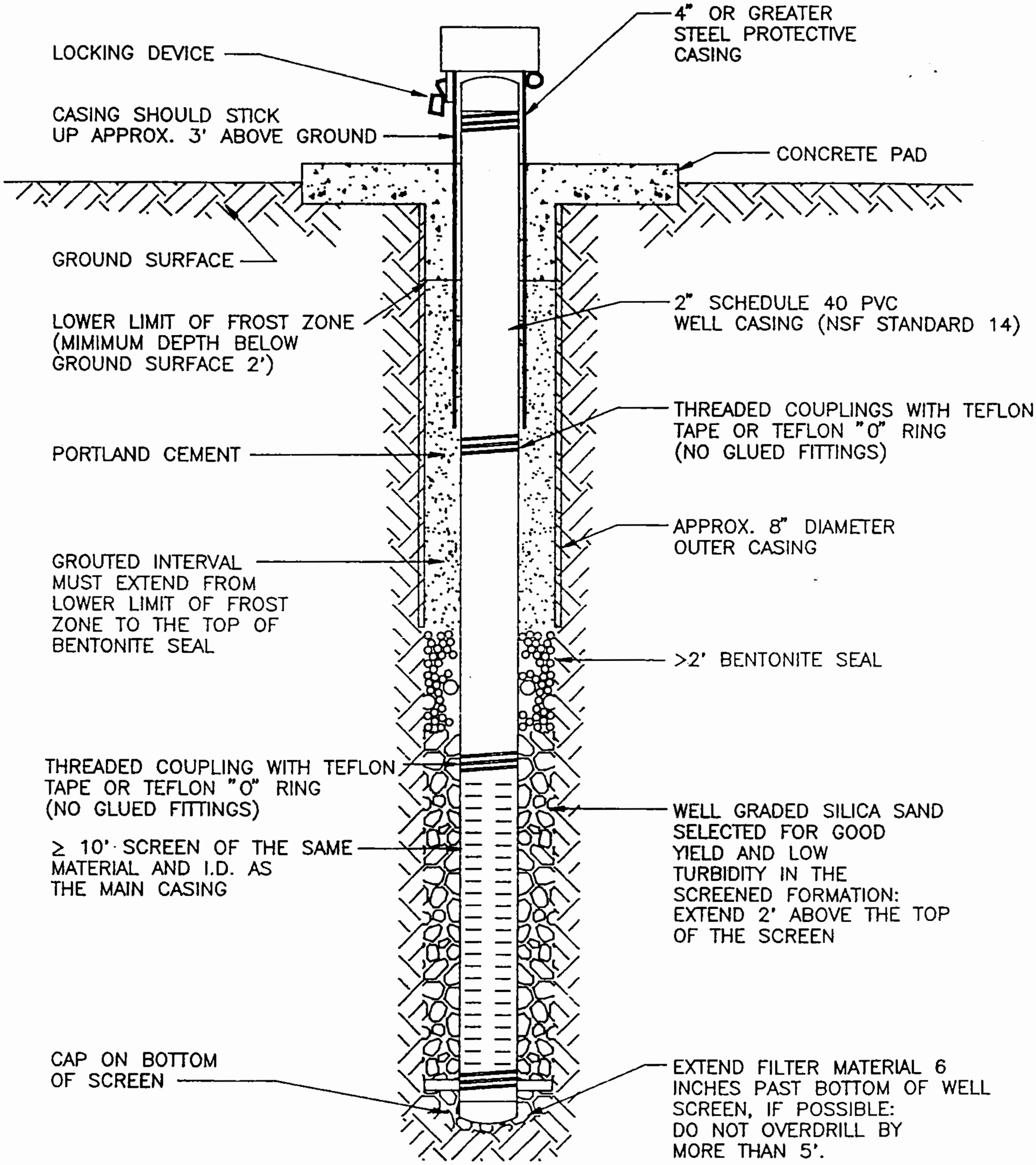
TYPICAL ILLUSTRATION OF MINIMUM SPECIFICATIONS FOR MONITORING WELL CONSTRUCTION



FINAL RFI CSAP NAVAL BASE CHARLESTON CHARLESTON, S.C.	FIGURE 5-2 CONFINED AQUIFER MONITORING WELL DESIGN
DWG DATE: 08/08/94	DWG NAME: 029MGWI

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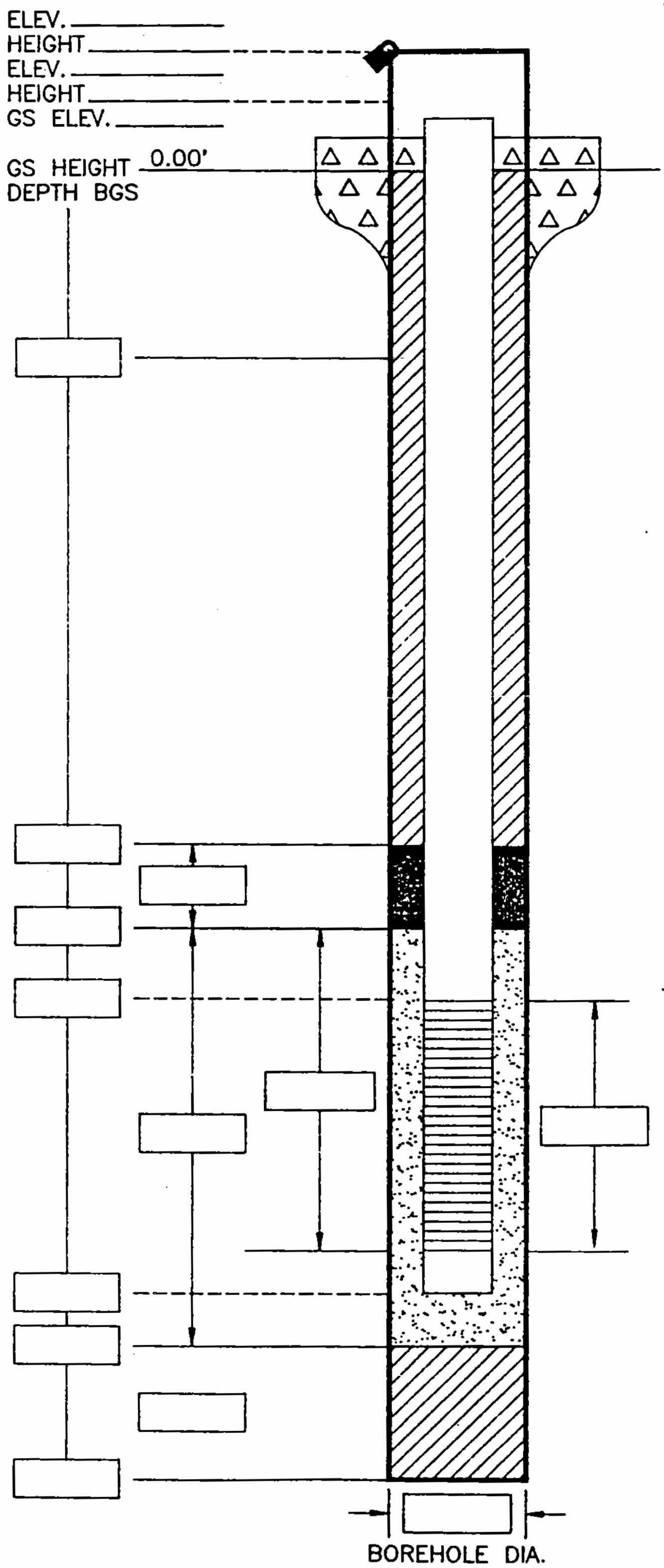
FIGURE 5-3

MONITORING WELL CONSTRUCTION LOG - STANDARD

WELL NO.:	INSTALLATION:	SITE:
PROJECT NO.:	CLIENT/PROJECT:	
CLEAN CONTRACTOR:	DRLG. CONTRACTOR:	
COMP. START: (____m)	COMP. END: (____m)	
BUILT BY:	WELL COORD.:	



PROTECTIVE CASING
MATERIAL/TYPE ____
DIAMETER ____
DEPTH BGS ____ WEEP HOLE(Y/N) ____

GUARD POSTS (Y/N)
NO. ____ TYPE ____

SURFACE PAD
COMPOSITION & SIZE ____

RISER PIPE
TYPE ____
DIAMETER ____
TOTAL LENGTH(TOC to TOS) ____
VENTILATED CAP (Y/N)

GROUT
COMPOSITION & PROPORTIONS ____

TREMIED (Y/N)
INTERVAL BGS ____

CENTRALIZERS (Y/N)
DEPTH(s) ____

SEAL
TYPE ____
SOURCE ____
SETUP/HYDRATION TIME ____
VOL. FLUID ADDED ____
TREMIED (Y/N) ____

FILTER PACK
TYPE ____
AMT. USED ____
TREMIED (Y/N)
SOURCE ____
GR. SIZE DIST. ____

SCREEN
TYPE ____
DIAMETER ____
SLOT SIZE & TYPE ____
INTERVAL BGS ____

SUMP (Y/N)
INTERVAL BGS ____ LENGTH ____
BOTTOM CAP (Y/N)

BACKFILL PLUG
MATERIAL ____
SETUP/HYDRATION TIME ____
TREMIED (Y/N)

48MWCLG2

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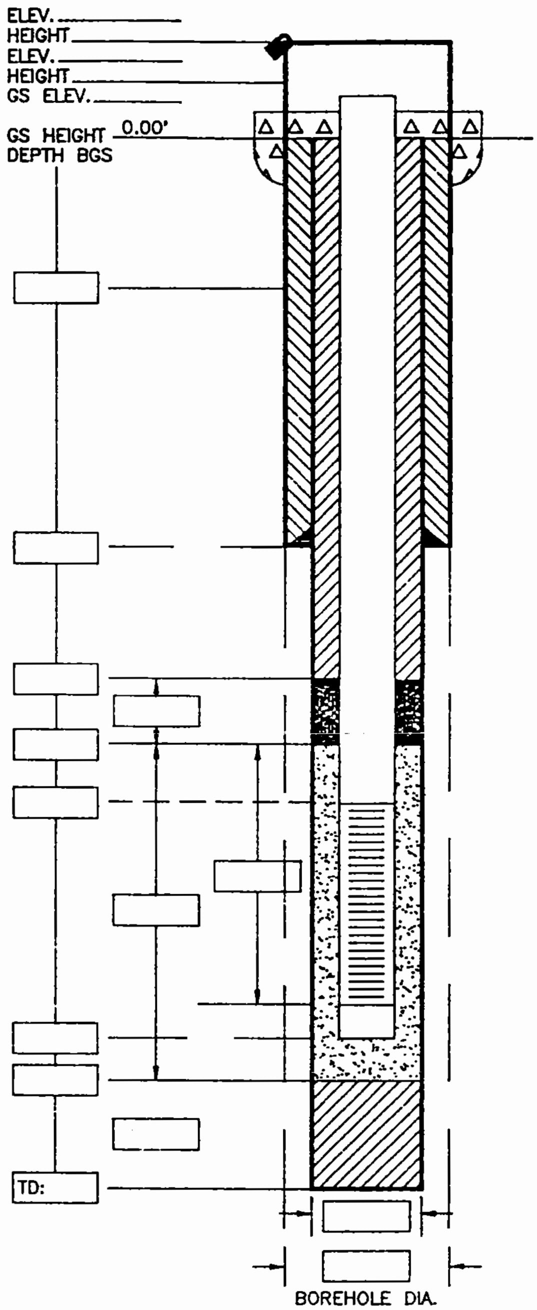
MONITORING WELL CONSTRUCTION LOG – CONFINED AQUIFER		
WELL NO.:	INSTALLATION:	SITE:
PROJECT NO.:	CLIENT/PROJECT:	
DRILLER:		
GEOLOGIST:		



PROTECTIVE CASING
MATERIAL/TYPE
DIAMETER
DEPTH BGS ____ WEEP HOLE(Y/N)

GUARD POSTS (Y/N)
NO. ____ TYPE

SURFACE PAD
COMPOSITION & SIZE

OUTER CASING
TYPE
DIAMETER ____ TOTAL LENGTH

RISER PIPE
TYPE
DIAMETER
TOTAL LENGTH(TOC to TOS)
VENTILATED CAP (Y/N)

GROUT SETUP/HYDRATION TIME
AMOUNT

TREMIED (Y/N)
INTERVAL BGS

CENTRALIZERS (Y/N)
DEPTH(s)

SEAL
TYPE
MFR.
SETUP/HYDRATION TIME
VOL. FLUID ADDED
TREMIED (Y/N)

FILTER PACK
TYPE
AMT. USED
TREMIED (Y/N)
MFR.
GR. SIZE DIST.

SCREEN
TYPE
DIAMETER
SLOT SIZE & TYPE

SUMP (Y/N)
INTERVAL BGS ____ LENGTH
BOTTOM CAP (Y/N)

BACKFILL PLUG
MATERIAL
SETUP/HYDRATION TIME
TREMIED (Y/N)

48MWCLG1

FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 5-4
MONITORING WELL CONSTRUCTION LOG – CONFINED AQUIFER

DWG DATE: 08/08/94 | DWG NAME: 48WMCG1A

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The drilling area will then be positively cleared using electromagnetic techniques. In highly developed areas a 5 foot pilot hole will be advanced manually prior to drilling.

During Installation:

Drill the Hole

3. For boreholes requiring soil sampling to the completion depth:
   - Advance the boring and conduct sampling in accordance with Section 4 of this CSAP until the borehole completion depth is encountered. The borehole should be at least 4 inches larger in diameter than the casing. Drill the hole slightly deeper — approximately 6 inches more than required for the combined length of casing and screen. Sound the final completion depth with a decontaminated, weighted tape before continuing.

   For boreholes not requiring soil sampling to the completion depth:
   - Advance the borehole to the required depth using a bit or auger flight with PVC plug. The borehole should be at least 4 inches larger in diameter than the casing. Drill the hole slightly deeper — approximately 6 inches more than required for the combined length of casing and screen. Sound the final completion depth with a decontaminated, weighted tape before continuing.
4. Condition the borehole by circulating drilling fluids (mud, water, or air), or by rotating augers without drilling until the hole is cleaned of cuttings. Remove cuttings from the area around the auger.

Prepare the Casing

5. Prepare the casing and screen for installation. Decontaminate the casing and screen in accordance with Section 15 of this CSAP. *Do not* clean the PVC casing and screen with hot water or solvent rinse.

6. Withdraw the drill rods and bit or the auger flights. (If installing casing through hollow-stem augers, skip this step. Withdraw auger flights after installing the casing.) Check depth of hole with a weighted surveyor's tape.
7. Hang the casing string, screen down, over or in the top of the borehole. Lower the casing string down to the bottom of the well.

Set the Casing

8. If a filter pack is required, prepare the dry sand.
9. When the casing string is set to the desired depth, hang the centered casing in place. There should be 2 to 3 feet of stickup once the well has been lowered to its final position, unless the wellhead is flush-mounted because of its location.

Install the Filter Pack

10. If the well is greater than 20 feet, install the filter pack through the tremie pipe. Six inches or more of filter pack material must be spotted at the bottom of the hole, under the screen. Withdraw the auger slowly so the filter pack is placed evenly around the screen without bridging. The filter pack will be installed to above the top of the screen.
11. Check depth to top of filter pack with a weighted tape.

Install Bentonite Seal

12. If well is deeper than 20 feet, tremie bentonite pellets (not powder) on top of the filter pack. Use pellets if the seal is to be seated below the water table. Granular, flake, or slurried bentonite may be used above the water table. Slowly withdraw the auger as the bentonite is added to ensure even placement of the seal around the annulus. Check the depth with a weighted tape. If possible, there should be at least 2 feet of bentonite above the screen.
13. Hydrate according to manufacturer's specifications or eight hours, whichever is greater.

Grout the Annular Space

14. Mix high solids bentonite and water (approximately 6 gallons to each 94 pound [lb] bag of cement) to make a pumpable slurry.

15. If well is deeper than 20 feet, tremie grout into the annulus. Slowly withdraw the auger as the annulus fills. Grout the well to within 2 to 4 feet of the surface. Note the amount of grout used in the field logbook.

16. After installing grout, dismantle and decontaminate equipment. Allow adequate cure time (~24 hours) for the grout before developing the well.

Construct Wellhead Pad

17. Mix and pour concrete for the wellhead pad. Concrete must extend to the top of grout. Each well will be surrounded by a 3 feet x 3 feet x 6 inches elevated, outwardly sloping pad. The pad will extend 6 inches below the ground surface. It may be convenient to first fill the annulus to the bottom of the pad form and then set the locking well cover or locking protective casing. After the protective casing has been installed, the remaining concrete should be poured into the pad form.

18. Finish the concrete pad so it slopes away from the wellhead in all directions with a minimum thickness of 6 inches. If weather warrants, cover the concrete until cured. Lock the well cover.

19. If the well design specifies traffic barriers, dig holes and install four steel protective posts (4 inches diameter, 6 feet length, 1/4 inch thickness and concrete filled ASTM A120) in concrete (separate from the concrete pad). Posts and concrete must extend to a depth of 2 feet.

After Installation:

20. Record appropriate construction/completion information in the field logbook and/or on appropriate field log forms.

21. Return to the well site after concrete has cured for at least 24 hours and remove the form. Drill two weep holes on opposite sides of the protective casing, just above the concrete pad.
22. Rivet the well identification plate on the protective casing.
23. Brush paint bumper guard posts with high-visibility yellow epoxy paint (American Association of State Highway and Transportation Officials [AASHTO] M220).

5.4.3 Monitoring Well Installation (Confined Aquifers)

Before Installation:

1. Make sure area is clear of all underground and overhead utilities, and clear vegetation and debris from monitoring well site.
2. Place plastic sheeting on ground near the area to hold decontaminated equipment.

During Surface Casing Installation:

Drill the Hole

3. Using hydraulic rotary or auger techniques, advance an oversized borehole through unconsolidated surface deposits to a depth of 2 to 3 feet into the top of the confining bed. The auger I.D. should be 4 inches larger than the casing's diameter.
4. Condition the borehole by circulating drilling fluid (mud, water, or air) or by rotating augers without drilling until the hole is cleaned of cuttings. While conditioning the borehole, prepare necessary length(s) of surface casing.

Prepare and Set the Surface Casing

(Follow these procedures for each separate aquifer to be cased off.)

5. Pressure grout the bentonite slurry to fill the portion of the borehole in the confining bed.
6. Insert the surface casing into the borehole and push firmly into the confining bed.
7. Mix cement/bentonite grout in accordance with Section E.3.5 of the ESDSOPQAM.
8. Begin pumping grout slowly to ensure even placement without bridging.

9. Allow grout to cure for at least 24 hours before proceeding.

Drilling and Installation of Monitoring Well

10. After the grout has cured, continue drilling with a smaller diameter bit or auger string. The borehole must be 4 inches larger than the casing diameter. Advance borehole to the desired depth. Drill the hole a few feet deeper than necessary to allow for cavings during casing placement. If more than one hydraulic unit will be encountered during drilling, the well must be cased in separate stages to prevent cross-contamination.
11. Condition the borehole by circulating drilling fluid (mud, water, or air) until the hole is cleaned of cuttings. Pull the drill string out of the borehole when no additional cuttings reach the surface. Check depth of the hole with a weighted surveyor's tape.

Prepare and Set the Casing String

12. Prepare the casing string in manageable sections while conditioning the borehole. Decontaminate the casing and screen in accordance with Section 15, but *do not* wash PVC materials with hot water or rinse with solvents. Tighten casing joints.
13. Insert first segment of the casing string and lower to a convenient height for adding the second casing segment.
14. Chock the casing, add the second segment, then release the chock and lower the casing. Repeat this process until the full casing string is hanging in the well.
15. Allow the casing string to hang in the well. Never allow casing strings with Schedule 40 PVC to sit on the bottom because the weight of the casing may significantly reduce the slot size and may cause the screen to collapse.

Install Filter Pack

16. If the well is to be completed without a filter pack, insert a decontaminated pump tube or submersible pump so unconsolidated sediments will collapse against the screen.

17. Lower a weighted surveyor's tape to make sure the formation sands or gravels have collapsed to a distance of 2 feet or more above the top of the screen. Continue pumping until sufficient collapse has occurred. If pumping does not cause collapse, then a filter pack should be spotted at the screen as described in the next step.
18. If a filter pack is required, as is most common, prepare the dry sand or sand slurry, then proceed from the previous step listed above.
19. Tremie the filter material through the augers. Slowly withdraw the augers so the filter pack is placed evenly around the screen without bridging. Six inches or more of filter pack material should be spotted at the bottom of the hole, under the screen. The filter pack will extend to approximately two feet above the top of the screen for any monitoring well installed at NAVBASE, unless a specific variance is requested by NAVBASE and is approved by the USEPA and SCDHEC. The filter pack will not span the confining layer under any circumstances.

Install Bentonite Seal

20. Tremie the bentonite slurry onto the top of the filter pack. Bentonite pellets will be used where the seal is installed below the water table. The bentonite seal must extend 2 feet into the confining layer, if possible. Slowly withdraw the augers as bentonite is added to ensure even placement around the casing without bridging.
21. If the bentonite seal is installed above the water table, hydrate the bentonite according to the manufacturer's specifications or eight hours, (not necessary if pure bentonite grout is used) whichever is greater.

Grout the Annular Space

22. Mix a high solids bentonite and water to make a pumpable slurry.
23. Pour the grout into the annulus. Slowly withdraw the augers as the annulus fills to ensure even placement. Grout the well to within 2 to 4 feet of the surface.

24. After installing grout, dismantle and decontaminate equipment. Allow adequate cure time (~24 hours) before proceeding with well development.

Construct Wellhead Pad

25. Mix and pour concrete for the wellhead pad. Concrete must extend to the top of grout. Each well will be surrounded by a 3 feet x 3 feet x 8 inches elevated, outwardly sloping concrete pad. The pad will extend 6 inches below the ground surface. It may be convenient to first fill the annulus to the bottom of the pad form and then set the locking well cover or locking protective casing. After the protective casing has been installed, the remaining concrete should be poured into the pad form.
26. If weather warrants, cover the concrete until cured. Lock the well cover.
27. Four steel protective posts (4 inches diameter, 6 feet length, 1/4 inch thickness and concrete filled ASTM A120) will be installed surrounding the well. Posts and concrete must extend to a 2-foot depth.

After Installation:

28. Record the appropriate construction/completion information in the field logbook and/or on the appropriate field logbook forms.
29. Return to the well site after the concrete has cured for at least 24 hours and remove the form. Drill two weep holes on opposite sides of the protective casing and just above the concrete pad.
30. Rivet the well identification tag to the protective casing.
31. Paint bumper guard posts with high-visibility yellow epoxy paint (AASHTO M220).

5.4.4 Temporary Monitoring Well Installation for Groundwater Screening (Unconfined Aquifers)

Before Installation:

1. Make sure area is clear of all underground and overhead utilities using Public Works Department utility maps. Clear vegetation and debris from piezometer site.
2. Place plastic sheeting on ground to hold decontaminated equipment.
3. If using a drill rig, align it to sampling location.

During Installation:

4. Hand-auger or drill with a rig to the desired depth.
5. Prepare the decontaminated screen with attached drive point for installation.
6. Drive the screen into the ground until the top of screen is approximately 1 foot above the surface. Keep the screen vertical while it is being driven. If needed, filter pack sand will be poured inside the well casing to just above the screen height during the installation of temporary wells.
7. Attach the decontaminated riser pipe segments to the screen and continue driving until the screen is at the correct depth.
8. The anticipated lifetime of the temporary monitoring well will be included with the request for monitoring well approval.

After Installation:

9. Cap the riser.
10. Decontaminate the equipment in accordance with the procedures in Section 15 of this document.
11. Record construction information in the logbook.

5.5 Developing Monitoring Wells

A monitoring well is developed after the bentonite grout in its annular space has cured at least 24 hours. Development restores the normal hydrologic conditions of the geologic formation near the borehole. Monitoring wells can be developed using various techniques such as bailing, surging and bailing, or surging and pumping. Wells with low aquifer recovery will be developed by bailing, or a combination of surging and bailing. Wells with high aquifer recovery will be developed by a combination of surging and pumping. *Before development* and *after development* procedures apply to surging, bailing, and pumping. All monitoring wells must be developed until temperature, specific conductivity and turbidity measurements stabilize and the well produces clear, sediment-free water. A log of these measurements must be maintained during development and submitted with the "as-built" well construction details.

Before Development:

1. Don personal protective clothing and equipment as required in the site-specific CHASP.
2. Cover the surface around the well with clean plastic sheeting to contain any spilled development water.
3. Open the well cover and check the wellhead's condition.
4. Measure the depth to static water level with an electronic water-level indicator.
5. Prepare the necessary equipment for well development in accordance with Appendix E, Section E.8 of the ESDSOPQAM .

During Development:

Wells may be developed by bailing, surging and bailing, or surging and pumping. These techniques are discussed separately but may be used either separately or in combination. Various pumps that may be used during well development include:

- Brainard Kilman hand pump
- Centrifugal pump
- Peristaltic pump

- Bladder pump
- Grundfos pump

Surging:

1. Attach rope or PVC rod to a surge block.
2. Lower the surge block into the monitoring well with rope or rods.
3. Raise and lower the surge block so groundwater will be surged in and out of the monitoring well screen.
4. Continue for approximately 10 to 15 minutes.
5. Remove the surge block from the well for decontamination.

Bailing:

1. Assemble and lower the decontaminated bailer into the monitoring well and begin bailing.
2. The monitoring well shall be developed until the water column is as free of visible turbidity as possible given the subsurface conditions (between 10 and 30 nephelemetric turbidity units [NTU]), and until the pH, temperature, and specific conductivity have stabilized to satisfy the following criteria.

Temperature:	within ± 1.0°C
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10 percent from the duplicate
Turbidity:	relatively stable

Pumping:

1. Prepare the decontaminated pump and tubing, and lower them into the well.
2. Begin pumping the well.
3. If the productivity of the monitoring well is low, it will be alternately pumped then left idle to recover. The onsite geologist will determine when development is complete based on normal development criteria.

4. The monitoring well shall be developed until the water column is as free of visible turbidity as possible given the subsurface conditions (between 10 and 30 NTU), and until the pH, temperature, and specific conductivity have stabilized to satisfy the following criteria.

Temperature:	within ± 1.0°C
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10 percent from the duplicate
Turbidity:	relatively stable

After Development:

1. Groundwater withdrawn from the monitoring wells during development will be placed in 55-gallon drums for disposal by the Navy in accordance with Section 16 of this CSAP.
2. Remove development equipment from the monitoring well and decontaminate (if required) in accordance with Section 15 of this CSAP.
3. Lock the well cover before leaving the site.
4. Record all pertinent information in the field logbook.

6.0 GROUNDWATER SAMPLING

Groundwater samples will be collected in accordance with Section 4.9 of the ESDSOPQAM, included in Volume V of the RFI Work plan, with the following additions and/or modifications. All purging and sampling of monitoring wells will be conducted by using either a peristaltic, bladder, or Grundfos-type (helical rotor submersible) pump with Teflon™ vacuum container, depending on the depth of the well. All pump tubing will be constructed of a Tygon™- or Teflon™-lined material. If a pump is ineffective or impractical for successful purging and/or sampling, a Teflon™ bailer with a stainless-steel leader will be used. Collecting groundwater level data during sampling is addressed in Section 10.6.

6.1 Groundwater Screening Techniques

6.1.1 Hydropunch

The Hydropunch is a stainless-steel and Teflon™ sampling tool capable of collecting groundwater samples without installing a monitoring well. Because the device is pushed or driven into position, it is most suitable for used in unconsolidated clay, silt, sand, and fine gravel. Only a small amount of water (approximately 40 ml) may be collected with this device at a time, therefore, Hydropunch is best used as a VOA screening tool. Installation and sample collection procedures are provided below.

1. Don protective clothing and equipment as the site-specific CHASP specifies.
2. Prepare the site by covering the surface with plastic sheeting and arranging the required equipment for convenient use.
3. Connect the decontaminated Hydropunch to a small-diameter drive pipe.
4. Drive the closed sampler with a 140-pound hammer or hydraulically push the sampler to the desired sampling depth, which is at least 5 feet below the static water level. Less than 5 feet of penetration will result in slow fill times, inadequate sample volume, or improper check valve function.

5. Open the Hydropunch by pulling up the drive pipe approximately 1.5 feet. Groundwater will then flow freely into the sampler under the aquifer's hydrostatic pressure.
6. When the sample chamber is full, retrieve the Hydropunch. As the tool is retracted, check valves close, trapping the groundwater in the sample chamber.
7. At the surface, transfer the groundwater from the Hydropunch to the appropriate sample container.
8. Place any IDW generated into designated drums for disposal by the Navy in accordance with Section 16 of this CSAP.

6.1.2 Temporary Monitoring Wells

Temporary monitoring wells are useful when a full suite of analyses is required. Except for the lack of grout, temporary monitoring wells are installed following procedures for permanent monitoring wells. Temporary monitoring wells also are developed, purged, and sampled using the same criteria as for permanent monitoring wells. Procedures for temporary monitoring well installation and development are provided in Sections 5.4 and 5.5 of this CSAP. Monitoring well purging and sampling are detailed in the following sections.

6.2 Purging Static Water

Field personnel will purge monitoring wells before collecting samples to remove stagnant water from the casing and surrounding borehole space.

General Purging Procedures

- Purge monitoring wells with a decontaminated pump.
- Monitoring wells will be purged of between three and five well casing volumes. In addition turbidity should be 10 NTU or less. Indicator parameters temperature, turbidity, specific conductivity, and pH will be measured in a sample of groundwater prior to purging and following removal of each well casing volume. If these parameters have stabilized after removal of three well casing volumes, then the well will be sampled. If

these parameters have not stabilized after removal of three well casing volumes, purging will continue until a maximum of five well casing volumes have been removed from the well. If the indicator parameters have still not stabilized after removal of five well casing volumes, then sampling will proceed. Contain purge water in a dedicated drum.

- Continue purging until three readings of specific conductance, temperature, and pH stabilize within 10 percent of previous reading.
- Begin sampling when purging is complete. Monitor groundwater turbidity. If high turbidity remains after purging three well volumes, the monitoring well may need to be redeveloped (see Section 5.5).
- Record well purging data in the field logbook and/or on the Groundwater Sampling Form provided in Figure 6-1.
- When purging is complete, allow monitoring wells to recharge before beginning sampling. Wells evacuated while purging will be sampled when sufficient volume has reentered the well. For this project, low recharge monitoring wells are defined as those with recharge rates not allowing sample collection within 12 hours of initial purging. These wells will be documented as *dry*. Specific procedures for monitoring well purging are provided below.

Before Purging:

1. Don personal protective clothing and equipment as the site-specific CHASP specifies.
2. Cover the surface around the well with clean plastic sheeting to contain water spilled during purging or sampling.
3. Check condition of the wellhead, protective casing, and lock.
4. Open the well cover and monitor the breathing zone using a PID and FID to measure ionizable organic vapors. If vapors are detected, an interface probe will be used to determine the thickness of free product if present. If product is present, a one-way check ball valve will be used to sample the layer.

5. Measure static water level to the nearest 0.01 foot using an electronic water-level indicator. Record the measurement in the field logbook or on the groundwater sampling field form (Figure 6-1).
6. Calculate static volume using the following formula, taken from Section 4.9.7.2 of the ESDSOPQAM.

During Purging:

7. Prepare the decontaminated pump, and lower into the casing.
8. Begin purging the well; purge at least three volumes of water (water column).
9. Withdraw groundwater until temperature, pH, and conductivity have stabilized. A monitoring well is stabilized when three readings each of temperature, pH, and specific conductivity are within ±10 percent of the previous reading.
10. Purge upgradient and background wells before downgradient wells to reduce the cross-contamination risk.
11. While purging the well, conduct free chlorine and sulfide spot checks on the purge water.

Free Chlorine Spot Check:

- Place drop of purge water on the potassium iodide (KI) test paper.
- If paper turns blue, free chlorine is present. Cyanide samples will require preservation as described in Section 11.2 of this CSAP.

Sulfide Spot Check:

- Place drop of purge water on the lead acetate test paper.
- If paper turns bluish-black, sulfide is present. Cyanide samples will require preservation as described in Section 11.2 of this CSAP.

Figure 6-1
Groundwater Sampling Form

Groundwater Sampling — Sample ID: ______

PROJECT NAME: ______ **JOB NO:** ______ **DATE:** ______

WELL NO.: ______ **LOCATION:** ______

WEATHER CONDITIONS: ______ **AMBIENT TEMP:** ______

REVIEWED BY: ______ **PERSONNEL:** ______

PURGING DEVICE

Type device? ______

How was the device decontaminated? ______

How was the line decontaminated? ______

Which well was previously purged? ______

SAMPLING DEVICE

Type device? ______

How was the device decontaminated? ______

How was the line decontaminated? ______

Which well was previously sampled? ______

INITIAL WELL VOLUME

Well diameter (in.) ______

Stickup (ft.) ______

Depth to bottom of well from TOC (ft.) ______

Depth to water surface from TOC (ft.) ______

Length of water (ft.) ______

Volume of water (ft.) ______

(gal.) ______

Amount of sediment at bottom of well (ft.) ______

3 Volumes of water (gal.) ______

PURGING

Time started ______ Finished ______

Volume purged ______

Comments on Well Recovery ______

Depth to water (ft.) ______

Completion ______

Additional Comments ______

Sample Collected: Start ______

Finish ______

IN-SITU TESTING

Time:	___	___	___	___	___	___	___
	1	2	3	4	5	6	7
Well Volume Purged (gal.)							
Turbidity							
Odor							
pH (units)							
Conductivity (μmho)							
Water Temperature (°C)							
Depth to water (ft.)							

NOTES: 1 ft. length of 4" = 0.087 ft³ or 0.65 gal. 1 ft. length 2" = 0.022 ft³ or 0.16 gal.
Turbidity choices: clear, turbid, opaque
Revision Date: 8/5/92

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Static Volume Formula:

$$V = 0.041\ d^2h$$

Where:

V = volume of water in gallons
d = diameter of well in inches
h = depth of water in feet (total well depth - static water level)

The static volume may also be calculated using the following formula:

$$V = hr^2(0.163)$$

Where:

V = volume of water in gallons

h = depth of water in feet (total well depth - static water level)

r = radius of well in inches

After Purging:

12. Record data in the field logbook and/or on the Groundwater Sampling Form (Figure 6-1).
13. If well is purged dry, allow it to recharge before sampling. However, every effort should be made to avoid purging the monitoring well dry.
14. Document the wells as *dry* if it does not recharge within 12 hours of initial purging.
15. All IDW produced while purging will be drummed for disposal by the Navy in accordance with Section 16 of this CSAP.

6.3 Groundwater Sampling

Groundwater samples will be collected in accordance with the procedures in Section 4.9 of the ESDSOPQAM manual with modifications outlined below. Monitoring wells will be sampled with either a decontaminated pump or Teflon™ bailer. The type of pump used during sampling of monitoring wells must be a peristaltic pump, or another similar type of pump which will not chemically or physically alter groundwater samples.

- Newly installed wells will be allowed to recover for a period of two weeks before sampling.

- Peristaltic pumps will be used instead of bailers for purging and sampling when turbidity is greater than 10 NTU.
- Collect samples using a decontaminated pump with a Teflon™ vacuum container so that groundwater does not touch the pump. If a pump is ineffective or incapable of successfully sampling the monitoring well, a Teflon™ bailer may be used. When collecting VOA samples using a peristaltic pump, fill the tubing with sample then disconnect the tubing and cap. Withdraw the tubing from the well and uncap the tubing allowing the water to flow into the sample vial.
- Measure temperature, pH, and specific conductance for each sample collected and record in the field logbook or on the groundwater sampling form (Figure 6-1).
- Chemically preserve samples as specified in Section 11. After chemical preservation and labeling, chill the samples to 4°C.
- Record weather at the time of sample collection in the field logbook. Refer to specific procedures for groundwater sample collection provided below.

Before Groundwater Sampling:

1. Don protective clothing and equipment as site-specific CHASP specifies.
2. Prepare the site by covering the surface around the wellhead with plastic sheeting and arrange the required equipment for convenient use. If onsite decontamination is required, arrange the necessary supplies nearby in a separate location away from the wellhead.
3. Purge the well according to the procedures in Section 6.2 of this plan. If bailing, allow the water level to recover enough to completely submerge the bailer without touching the well bottom.
4. If bailing, securely attach the bailer to decontaminated Teflon™-coated stainless-steel leader. Then, securely attach the leader to the line. The end of the line also should be secured so the bailer is not lost down the well.
5. Arrange the sample containers in the order of sample collection. Groundwater samples will be collected in the following order (preented by Fred Sloan: volatile organic

analysis, dissolved gases and total organic carbon, semi-volatile organic analysis, metals and cyanide, major water quality cations and anions, and radionuclides.

During Groundwater Sampling:

6. Slowly lower the pump hose or bailer into the water to prevent aeration, particularly when VOA and SVOA samples are being collected.
7. Start pump or retrieve full bailer to the surface. If bailing, do not allow the line to touch the ground.
8. Unless the same pump or bailer is used for both purging and sampling, allow initial water from pump to discharge into drum or, if using a bailer, use the first bailer of water to rinse out the bailer; discard the water.
9. If using a bailer, repeat Steps 7 and 8.
10. When collecting VOA samples from pump discharge, decrease flow rate. If using bailer, either fill the VOA vials from the top of the bailer or attach VOA bottle filler to the bailer's base. For VOA samples, the sample bottles should be tilted when filling to prevent aeration. Check the filled vial for bubbles, making sure it has zero headspace.
11. Perform sample filtration with a 0.45-micron filter as soon as possible after sample retrieval, if required for the cyanide samples based on the sulfide spot check. Samples collected for total metals analysis will not be filtered.
12. If using a bailer and, after collecting VOA and SVOA samples, the remaining water is insufficient to completely fill another container, discard it. Lower the bailer again to collect more water for additional sample volume.
13. Fill the remaining sample containers to capacity. Add preservative (if needed), cap, seal, and properly label all containers. Place the filled containers in the cooler(s) immediately and preserve to 4°C.
14. If the free chlorine or sulfide spot checks are positive, preserve the cyanide samples in accordance with Section 11.2 of this CSAP.

After Groundwater Sampling:

15. Record sample identifications, types and amounts collected, as well as the time and date of collection in the field logbook and/or on the groundwater sampling form. Prepare chain-of-custody and analytical request documents as required in Section 11.6 of this plan.
16. Decontaminate sampling equipment if it is not dedicated to the monitoring well.
17. Clean up the area and place disposable materials (plastic sheeting, gloves, rope) in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
18. Close and lock the well cover.

7.0 SEDIMENT/SURFACE WATER SAMPLING PROCEDURES

7.1 Designating Sediment/Surface Water Sample Collection Locations

Sediment and surface water sample collection locations will be designated to comply with the sample identification system presented in Section 11.4 of this CSAP to facilitate sample data management. Sediment and surface water collection locations will be designated according to SWMU (first three digits), media to be sampled (one matrix digit), and the unique well number (four digits). For example, if a sediment sample were collected from sampling location 16 at SWMU 21, the collection location identifier would be "021M0016." Another example: If both a sediment and a surface water sample were collected at location 12, SWMU 2, the locations would be identified by "002M0012" and "002W0012," respectively. Proper attention must be given to ensure unique numbers are assigned to all sampling locations.

7.2 Sediment Sampling

Procedures for sediment sampling will adhere to the guidance presented in Section 4.8 of the ESDSOPQAM (included in Volume V of the RFI Work Plan), which lists several acceptable sampling techniques (dredging, scooping, coring) for collecting sediment samples from surface water bodies and dry land areas, depending upon sampling objectives. Sediment samples generally will be collected to a maximum depth of 6 inches. Several general precautions must be followed to provide a representative sediment sample and to minimize disturbance regardless of sampling technique.

General Sediment Sampling Precautions:

- Avoid sediment plumes and density currents.
- If sediment and surface water samples are to be collected at the same location, collect the surface water first.
- Sediment sampling locations may be reached by wading or by boat, depending upon water depth and the substrate's nature. If wading to the sample location, approach from downstream to minimize disturbance.

Specific procedures for sediment sampling by dredging, coring, and scooping are discussed below. Any variations from the procedures will be discussed in the site-specific SAP.

7.2.1 Dredge Samples

A Ponar grab sampler will be used to collect underwater dredge samples. The Ponar sampler is a steel, clam-shell type scoop activated by a cantilevered system. Procedures for operating the Ponar grab sampler are provided below.

Before Dredge Sampling:

1. Don personal protective clothing and equipment as the site-specific CHASP specifies.
2. Lock open the jaws of the decontaminated sampler.

During Dredge Sampling:

3. Lower the sampler into the sediment.
4. Release tension on the rope and close sampler jaws.
5. Retrieve the sampler and open the jaws to collect the sediment sample.
6. To collect the VOA sample, either push a stainless-steel sleeve into the dredge sampler and cap, or release the sediment sample into a stainless-steel bowl and immediately collect the VOA samples. Fill the sample containers to capacity to achieve zero headspace.
7. Repeat the sample collection process (Steps 3 to 5) until enough volume has been collected to make the necessary composite samples. Homogenize the material in the stainless-steel bowl in accordance with ESDSOPQAM procedures and place in appropriate sample containers, using stainless-steel implements.
8. Describe lithology of sample collected and sample collection depth in the field logbook.

After Dredge Sampling:

9. Upon completion of sampling, decontaminate all equipment in accordance with Section 15 of this CSAP.

7.2.2 Core Samples

Coring is a useful sampling technique because it preserves any sequential layering of the sample and provides a historical profile. In addition, coring minimizes sediment disturbance caused by shock waves and, if used in conjunction with insertable sleeves, it minimizes the cross-contamination risk. Core samples will be collected in areas where samples must be collected at depths greater than 6 inches.

Coring Equipment: A Wildco-type or modified stainless-steel split-barrel push tube sampler with a 2-inch-diameter, 2-foot-long sample barrel will be used. These devices will be used with or without insertable 12-inch or 6-inch Teflon™ or stainless-steel sleeves. If sleeves are used to collect analytical samples, a second core will be collected at the location *without* sleeves for lithology description. Extension rods will be used offshore to collect samples in water deeper than wading depth. Procedures for collecting samples with the coring devices follow.

Before Core Sampling:

1. Locate the sample collection location on the site map and reference it appropriately in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.
3. Place a decontaminated stainless-steel sampling sleeve inside the decontaminated sampler.

During Core Sampling:

Note: Except for VOA samples, all samples collected in sleeves will be composited and homogenized before laboratory analysis.

4. Drive the full length of sampler into the substrate.
5. Carefully remove the sampler from the substrate.

Samples collected with stainless-steel sleeves:

6. Remove sleeves from the sampler, minimizing disturbance.
7. Immediately install Teflon™ septa over the liner ends and seal with PVC caps.
8. These cores will be submitted to the laboratory for analysis in accordance with the site-specific SAP.

Samples collected without stainless-steel sleeves:

9. Extract sediment from the sampler and immediately fill the VOA container. Be sure the sample container has zero headspace.
10. Remove the remaining sample volume and place in a stainless-steel bowl. Homogenize the sample in accordance with ESDSOPQAM procedures with a stainless-steel spoon or spatula.
11. Fill the remaining sample containers.
12. Label the samples and preserve to 4°C. Mark top of the sample on outside of the liner.
13. Repeat above sampling procedures for a second 24-inch core *without* the sleeves. This core will be examined, but not disturbed, in the field by a geologist, who will describe sample lithology using the USCS.

Special Precautions for Deep Underwater Core Sampling:

A boat will be required for sampling sediment in water deeper than wading depth. Extension rods for sampler and/or diver assistance may be required in deep water. Although sampling procedures will be the same as the procedures listed above, special precautions must be taken:

- Cap top of the sampler while it is in the substrate to prevent suction during extraction from extruding the sample through bottom of the sampler.

- When the sampler is free from the substrate, cap bottom end before removing from the water.
- In deeper water, have a diver cap the sampler and assist in sampling.

After Core Sampling:

14. Decontaminate sampling equipment in accordance with Section 15 of this CSAP.
15. Record all pertinent information in the field logbook before leaving the site.
16. Place contaminated disposable materials in a designated drum for disposal by the Navy.

7.2.3 Scoop Samples

Samples from sediment buildup in constructed drains, gutters, or other impervious surfaces will be acquired with a stainless-steel spoon and bowl. Procedures for scooping are provided below.

Before Scoop Sampling:

1. Locate the sample collection location on the site map and reference it appropriately in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.
3. Place clean plastic sheeting on the surface near the sample collection location to hold decontaminated sample collection equipment.

During Scoop Sampling:

4. Scrape the sediment surface with a decontaminated stainless-steel spoon or spatula to reach a previously unexposed surface.
5. Scoop the sediment with a decontaminated stainless steel-spoon or spatula.
6. For Grab or VOA samples:
    - For VOA samples completely fill the sample containers directly from the sampling device, avoiding twigs, large rocks, and grass. For remaining analytes, thoroughly homogenize the sample prior to containerization.

- Be sure to have zero headspace in the VOA sample container.

For Composite samples:

- Empty contents of the sampling device into a decontaminated stainless-steel or Teflon™-lined bowl. Collect enough sample to fill all the containers.
- Homogenize sample in accordance with ESDSOPQAM procedures.
- Place mixture into the appropriate containers.

For Toxicity samples:

- Empty contents of the sampling device into appropriate sample container.
- Collect sufficient sample to fill all the containers.

7. Secure container with Teflon™-lined cap.
8. Label each sample container with appropriate information.

After Scoop Sampling:

9. Place the samples in a cooler and preserve to 4°C.
10. Record pertinent information in the field logbook.
11. Place contaminated disposable materials in the designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.
12. Decontaminate sample equipment in accordance with Section 15 of this CSAP.

7.3 Surface Water Sampling

Surface water will be sampled in accordance with Section 4.8 of the ESDSOPQAM, included in Volume V of the RFI Work Plan. The samples will be collected either by placing the sample bottle in the surface water body or by using a Kemmerer sampling device. After selecting sample locations, the number of samples to be collected will depend on the following criteria:

- Water depth
- Estuarine or fresh water
- Tidal influence
- Salinity profile
- Type of water body (lake, stream, impoundment, or wetland)

Where the water depth is greater than 3 feet, surface water quality parameter measurements (e.g., dissolved oxygen, temperature, pH, conductivity, salinity, and depth) will be collected at the following depths: 1 foot below the water surface, mid-depth, and 1 foot above the bottom.

General Surface Water Sampling Concerns:

- Collect samples from areas of least to greatest contamination and from upstream to downstream.
- Approach surface water sample locations from downstream to minimize sediment disturbance.
- In tidal areas, sample collection should be made at slack tide, preferably low slack.
- Collect samples so as to minimize agitation of underlying sediments.
- If surface water samples and sediment samples are to be collected at the same location, collect the surface water sample first.
- Determine the number of sample collection depth at the sample location.
  - If water is less than 1 foot deep, collect one sample at the surface.
  - If water is more than 1 foot and less than 10 feet deep, the sample shall be collected at mid-depth unless the salinity profile indicates the presence of a halocline (salinity stratification). If a halocline is present, a surface water sample shall be collected from each stratum.
  - If water is more than 10 feet deep, collect samples at 1 foot depth, mid-depth, and 1 foot above the bottom.

Surface water sample collection procedures for both submerged bottle and Kemmerer devices are discussed below.

7.3.1 Submerging Laboratory Bottle

Submerging the laboratory bottle is feasible only for surface water sample locations accessible by wading. If samples are to be collected from more than one depth, or if the sample location is not accessible by wading, another method should be used.

Before Sampling with Laboratory Bottle:

1. Locate the sample collection location on a site map and describe it in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.

During Sampling with Laboratory Bottle:

3. Point open end of vials upstream. Slowly submerge unpreserved VOA vials and fill. Do not disturb bottom sediments. If the sample is to be collected at depth, uncap the bottle at the required sampling depth. Recap containers before returning bottle to the surface.
4. Cap the VOA vial underwater. Be sure to have zero headspace before sealing it.
5. If VOA vials are pre-preserved, collect surface water samples with a decontaminated glass or stainless-steel device and carefully decant into VOA vials.
6. Slowly submerge other unpreserved bottles into the surface water and fill. If the sample is to be collected at depth, uncap containers at the required depth and allow to fill. Recap the containers before returning sample to the surface.
7. Chemically preserve the samples as needed and seal with Teflon™-lined caps.
8. Collect additional surface water in the sample collection device for field measurement of pH, temperature, and conductivity. If the sample interval is at depth, probes will be used to measure these parameters. Other parameters may be added as the site-specific SAP requires.

After Sampling with Laboratory Bottle:

9. Place bottles in cooler and preserve to 4°C.
10. Note pertinent sampling information, including the tidal phase, in the field logbook.
11. Decontaminate all sampling equipment in accordance with Section 15 of this CSAP.

7.3.2 Kemmerer Sampler

Use a Kemmerer or similar sampling device when samples are needed at discrete intervals in a vertical water column. A Kemmerer is a cylinder with Teflon™ stoppers on the ends. The Teflon™ stoppers are open while the device is being lowered in a vertical position so water can pass freely through the cylinder. When the Kemmerer has reached the designated sampling interval, a weight (messenger) is dropped down the rope to close the device. Specific procedures for surface water sampling with a Kemmerer sampler are provided below.

Before Kemmerer Sampling:

1. Locate the sample collection location on a site map and describe in the field logbook.
2. Don personal protective clothing and equipment as the site-specific CHASP requires.
3. Determine the number of sample collection depths at the sample location.

During Kemmerer Sampling:

4. Lower the decontaminated Kemmerer device to the designated depth.
5. Drop a messenger down the rope to close the cylinder.
6. Raise the Kemmerer device.
7. Immediately fill VOA vials. Make sure there is zero headspace, chemically preserve the sample if needed, and secure with a Teflon™-lined cap.
8. Fill remaining bottles. Continue to collect sample volume from each designated depth until all bottles are filled.
9. Measure field parameters of pH, temperature and conductivity, and record in the field logbook at each sample depth.
10. Repeat procedure for each designated sample interval.

After Kemmerer Sampling:

11. Place bottles in cooler and preserve to 4°C.
12. Note sampling information in the field logbook.
13. Decontaminate all sampling equipment in accordance with Section 15 of this CSAP.

8.0 AIR SAMPLING

8.1 Soil-Gas Survey

A standard soil-gas survey is an effective screening tool for VOA contamination and is useful for establishing soil and groundwater sampling points. This survey will require establishing a grid system across the site to be surveyed, using procedures outlined below, then collecting samples at each of the established grid points.

Establishing the Grid System:

1. A South Carolina-registered surveyor or E/A&H personnel will define the two baselines (x and y axes) and record the baselines and other key elements of the grid on report maps.
2. The baselines will be flagged at regular intervals, according to the site-specific SAP.
3. The internal grid points will then be established using a Brunton compass and measuring tape.

General Soil-Gas Sampling Procedures

1. Collect measurements at each established grid point and record the values in the field logbook. If necessary, further investigate areas of elevated soil-gas readings by redefining the survey grid to a smaller interval.
2. Collect additional soil-gas readings at the redefined grid nodes. If the elevated readings need further definition, decrease the survey to smaller intervals as needed.
3. Note the sampling points on a site map.
4. Install the soil-gas probes using either a manual disposable drive-point method or a hydraulically powered, van-mounted probe.
5. Field control samples will be collected by drawing pre-purified nitrogen or filtered ambient air through the sampling apparatus and probe. Field control samples will be collected before each day's sampling activities, after every 20th sample, and after each day's sampling activities.

6. Between each sampling location, decontaminate the soil-gas probe. *Do not* use solvents. *Do not* re-use Teflon™ tubing.
7. Place any IDW into 55-gallon drums for disposal by the Navy.

Sample Collection with a Perforated Drive-Point

1. Assemble the soil-gas sampling point of stainless-steel pipe to a disposable sampling point.
2. Decontaminate the stainless-steel drive point assembly before use and advance it to slightly above the water table.
3. Use Teflon™ tubing to connect the soil-gas sampling point to the sample collection device; attach a vacuum pump with additional Teflon™ tubing.
4. Purge at least two sample volumes before collecting samples.
5. Collect sample in a pre-evacuated glass vial at two atmospheres of pressure.
6. Detach the self-sealing vial and analyze the sample with a portable gas chromatograph (GC).
7. Remove the sampling point.

Sample Collection with a Van-Mounted Probe

1. Advance the stainless-steel pipe, outfitted with a disposable stainless-steel tip on the lead drive point, into the ground with the percussion hammer.
2. After the pipe has been advanced to the desired depth, disengage the drive point and withdraw the drive pipe 8 to 10 inches to create a void in which soil gases can collect.
3. Insert the Teflon™ sample tubing into the drive pipe and connect the tubing to a sample collection device. Use additional Teflon™ tubing to attach to a vacuum pump.
4. Purge at least two volumes from the sampling apparatus before collecting samples.
5. Collect the sample in a pre-evacuated glass vial.
6. Detach the self-sealing vial and analyze the sample with a portable GC.
7. When sample collection is complete, remove the stainless-steel sampling tube.

8. Decontaminate all sampling equipment before use and between each sample collection point. *Do not* use solvents. *Do not* reuse Teflon™ tubing.
9. Place the IDW in 55-gallon drums for disposal by the Navy.

8.2 Passive Soil Gas

Passive soil-gas is a useful technique for collecting and detecting trace quantities of VOA and SVOA from the subsurface at the earth's surface. VOA and SVOA are adsorbed onto the passive soil-gas sampler over a few hours to a few weeks. Because of the increase in the sampling period, the detection limits for many compounds and the temporal variations in the analyses are lower than standard soil-gas techniques. The sampler consists of two or three collectors, each a ferromagnetic wire coated with an activated charcoal adsorbent in a screw-top glass culture tube. Collectors will be checked for cleanliness using mass spectrometry before release to the field.

Before Sampling

1. Don personal protective clothing and equipment as the site-specific CHASP requires.
2. Stake the location(s) to be sampled.
3. Decontaminate installation equipment in accordance with Section 15 of this CSAP.

Installing the Sampler

Installation methods will vary depending on surface conditions. If the surface is grassy or otherwise loosely consolidated, a coring shovel will be used. If the surface is concrete, asphalt or otherwise consolidated, an electric rotary hammer will be used. Both techniques are detailed below.

Loosely Consolidated Surface Conditions

1. Using a coring shovel, core a 14-inch-deep by 2-inch-diameter hole in the surface soil.
2. Place the soil-gas sampler open end down at the bottom of the hole.

3. Backfill the hole with an aluminum foil plug and the original excavated soil.
4. Mark the sample location with ribbon flagging and a number pin flag.
5. Detail all pertinent information in the field logbook before leaving the sampling location.

Consolidated Surface Conditions

1. Using an electric rotary hammer, drill an 18-inch by 1.5-inch-diameter hole (e.g., the drill bit dimensions) through the surface.
2. Attach a cleaned galvanized steel wire to the sampler and lower to the bottom of the hole.
3. Plug the hole with aluminum foil to approximately 2 inches below grade.
4. Cap each hole to land surface with hydraulic cement to protect the sampler from the surface environment.
5. Mark the sample location with ribbon flagging and a number pin flag.
6. Detail all pertinent information in the field logbook before leaving the sampling location.

Duration of Sampler Exposure

The length of time the samplers are exposed to soil gas will be determined by using time-calibration samplers. These samplers measure loading rates of volatile and semivolatile organic compounds emanating from the soil gas. Two sets of three to five time-calibration samplers will be installed in the AOC to represent the range of soil-gas response. These locations will be selected based on known site conditions including groundwater gradient and potential source areas. Generally, the first set of time-calibration samplers are retrieved after approximately one week. The second set of time-calibration samplers will be retrieved after approximately two weeks. At the first indication of significant ion count intensities and significant total ion count values, all of the samplers will be retrieved. If the second set of time- calibration samplers show no significant ion count intensities, the samplers are allowed to equilibrate for up to 30 days.

Retrieving the Sampler

Retrieving the sampler will depend on the surface conditions. Both techniques for retrieval are detailed below.

Loosely Consolidated Surface

1. Expose the backfilled sampler with a trowel.
2. Using a pair of tongs, lift the sampler to the surface.
3. Seal, clean, and label the sampler.
4. Backfill the hole with the original material and clean fill, as required.

Consolidated Surface

1. Remove the hydraulic cement pad and expose the sampler using a hammer and chisel.
2. Using the steel wire, lift the sampler to the surface.
3. Seal, clean, and label the sampler.
4. Backfill the hole with the original material and clean fill, as required.
5. Patch the surface with cement or asphalt.

Quality Assurance/Quality Control

Each sampler contains two or three collector wires that should have adsorbed identical compounds. The first and second wires are analyzed by thermal desorption/mass spectrometry (TD/MS). If the two analyses are similar, no further analysis is necessary for the sampler. If data vary, the second wire will be analyzed by thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS).

Approximately 10 percent of the samplers will contain a third wire to be used for quality control. The wire is used to test the mass spectrometer's operating conditions before survey analysis. In addition, the third wire may be used to test the sensitivity of the analyses or to compare the reproducibility of detected VOA.

Two samplers will be included to act as travel blanks used to check for contamination introduced during shipment.

8.3 Ambient and Indoor Air

Both ambient and indoor air quality samples for VOA analysis will be collected into evacuated stainless-steel Summa™ canisters as described in Section 4.13.2 of the ESDSOPQAM and the *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*. The canister may be used to collect grab samples or integrated composite samples over a prescribed time. The following procedures should be followed when collecting air samples.

1. Don personal protective clothing and equipment as the site-specific CHASP requires.
2. Select the sampling.
3. Before collecting the sample, attach a sample label to the canister detailing the location, time of collection, interval, and the signature of the person collecting the sample. Labels will be prepared in accordance with Section 11.4 of this CSAP.
4. For grab samples:
   - Fit the canister inlet valve with a clean stainless-steel particulate filter.
   - At the sample collection location, open the main valve and allow the canister to fill.
   - After approximately one minute or until there is no audible sound of rushing gas, close and cap the main valve of the canister.

   For composite samples:
   - Attach a vacuum flow regulator to the canister to control the sampling period. Adjust the flow rate so the ending pressure of the canister is approximately 0.9 atmospheres (atm). Record the initial flow rate and vacuum.
   - Allow the canister to fill for the designated interval then close and cap the container.

5. Complete the chain-of-custody form (see Figure 11-3) and package canister for shipment to the selected laboratory according to the guidelines in Section 11.3 of this CSAP.

9.0 MISCELLANEOUS SAMPLING TECHNIQUES

9.1 Wipe Sampling

Wipe sampling may be necessary to evaluate whether miscellaneous non-absorbent surfaces of walls, floors, equipment, etc., are contaminated. Ideally, the surface should be horizontal and facing upward since surfaces in this position generally are most susceptible to spills and settling dust, but this is not always the case.

All wipes in the jar will be used in accordance with Section 4.12.6 of the ESDSOPQAM, included in Volume V of the RFI Work Plan. Samples will be collected by swabbing or wiping the material or surface with pre-prepared gauze pads that are saturated with either methylene chloride, certified pesticide-grade hexane, or deionized water, depending on the parameters to be analyzed. The wipes will be supplied by the analytical laboratory in an 8-ounce precleaned glass jar. The wipes are to be removed from the sample jar using tweezers or gloves. The entire area to be sampled is wiped with firm strokes using only one side of the wipe. The wipe is then returned to the sample jar from which it was taken. Care should be taken to tightly reseal the jar to prevent evaporation of the solvent. The sample jar will be labeled in accordance with the procedures outlined in Section 11.4 of this CSAP.

A new pair of disposable gloves shall be worn to collect each individual wipe sample. The area sampled in square centimeters shall be noted on the chain-of-custody form (see Figure 11-3) and in the field logbook. The optimal area is 100 square centimeters. In order to ensure a consistent sampling area, a 100 square centimeter template will be used. However, due to the nature of the matrices to be sampled, the optimal area may not be available. In instances where a 100-square-centimeter sample area is not available, the actual sampled area will be measured and noted on the chain-of-custody form, sampling log, and the field logbook.

9.2 Waste Sampling

The waste sampling program's basic objective is to produce a set of samples representing the waste media under investigation and suitable for subsequent analysis. This section describes the methods and materials that will be used for sampling waste generated at Navy installations. Under many circumstances, the sampling and testing performed for the investigation will be sufficient to classify the waste and no additional sampling will be necessary. When additional sampling is required to characterize the waste, it is important that quality control (QC) sampling is performed to assess the sampling program's accuracy and precision. QC sampling methods should be the same as those stated in the approved work plan.

Sampling accuracy usually is achieved by using a random sampling technique. Sampling precision is achieved by collecting the appropriate number of samples and by maximizing their physical size.

A simple random sampling strategy will be employed for most solid waste cases where additional samples are required to characterize the waste. The rationale for using this type of sampling method is that typically little or no information is known about the distribution of the chemical contaminants within the waste. For most solid waste, distinct strata within the containers are not identified and variations in composition or stratification may have occurred at unknown and random depths.

Simple random sampling is a type of probability sampling that relies on mathematical and statistical theories. In simple random sampling, all locations or portions of the waste have an equal chance of being sampled. For simple random sampling, the appropriate number of samples to be collected is estimated by finding the regulatory threshold (RT) for the contaminants of concern (COC) and by estimating the sample mean (x) and variance (s).

Simple random sampling may be used for liquid waste that is thought to be homogeneous. Stratified random sampling may be used for liquid waste sampling where the COC are thought to stratify due to their density relative to the other liquids. Stratified random sampling is different from simple random sampling in that x is calculated for each stratum in the population and then integrated into the overall estimates of those statistics. Systematic random sampling also may be used for instances where there are recognized trends or cycles associated with the contaminants in the waste. Cases where systematic random sampling may be used include drums with floating or sinking products.

It also is likely that if the waste is to be disposed of to a treatment, storage, or disposal facility (TSDF), its operators will want to perform their own waste characterization. Therefore, it is important to contact the potential TSDF before sampling and analyzing the waste to avoid duplicating efforts and costs. The potential TSDF for the waste should be contacted following environmental sampling. Their requirements regarding acceptable laboratory analyses change as do the wastes they are accepting and the rates they charge. Transportation requirements and costs should be determined before shipping.

The sampling method chosen for each of the waste media will, in part, be dependent on the potential contaminants of concern as shown by site history or analytical results of the field sampling program. The generation of additional decontamination fluids through waste sampling should be minimized and should be a factor considered in the final choice of sampling technique. Care should be exercised to avoid the use of sampling devices plated with chrome or other materials that might contaminate the sample.

The sampling methods for containerized media are divided into three sections that address (1) soil and sludges, (2) containerized liquids, and (3) containerized personal protective equipment (PPE). If required, wipe sampling will be used to analyze the surface of drums, disposable equipment, and PPE.

9.2.1 Soil and Sludge Sampling

Available options for sampling devices suitable for soil and sludge (or sediment) sampling include scoops, thin-walled tube samplers, hand augers, core samplers, and sampling triers. Using a scoop and a sampling trier 100 centimeters (cm) long is the recommended method for sampling containerized soil and sludge. However, site-specific conditions may necessitate a variety of sampling options, and therefore all of these sampling methods will be discussed. The presence of rocks, debris, or other sampling-specific considerations may complicate sampling and preclude using or require modification some of these sampling devices.

When sampling a previously sealed vessel, the presence of a bottom sludge should be checked. This is easily accomplished by measuring the depth to apparent bottom and then comparing it to the known interior depth. Methods for sampling a bottom sludge are described in the following sections. Sludges that develop in 55-gallon drums also can be collected by employing glass tubes used for the liquid portion of the sample.

9.2.2 Thin-Walled Tube Sampler

The thin-walled tube sampler is, as its name implies, a metal tube generally 2.5 to 7.5 cm in diameter and 30 to 60 cm long. The tube is forced into the soil or sludge and then extracted. Friction will usually hold the sample material in the tube during extraction. Interchangeable cutting tips facilitate penetration with reduced sample disturbance. Thin-walled tube samplers are available in various types and construction materials and are suitable for moist, dry, sandy, or heavy-duty applications.

Soil or sludge also can be sampled with a hand corer. This device is essentially the same type of thin-walled tube sampler described above. It is modified by adding a handle to facilitate driving the corer and a check valve on top to prevent washout during retrieval through an overlying water layer. Hand-auguring devices can be used in conjunction with a thin-walled tube sampler. In this manner, a thin-walled tube sampler can be used to sample both from the surface or to the bottom of a 55-gallon drum. However, the presence of rocks or the collapse of the auger hole generally prohibits sampling at depth.

9.2.3 Aqueous Liquid Sampling

Beakers, glass tubes, bailers, and extended bottle samplers and composite liquid waste samplers (COLIWASA) are devices that may be used to sample containerized liquid media. Site-specific conditions may necessitate a variety of sampling options, and therefore all of these methods will be discussed below. Samples from drums also can be readily collected by merely submerging a sample bottle.

Beakers

Using a sampling device such as a beaker, either disposable or constructed of glass, Teflon™, or stainless steel, is the recommended method for sampling containerized liquids. The device typically has a capacity of at least 500 ml to provide an adequate sample volume for analysis and to minimize the number of times the liquid will be disturbed, thus reducing agitation of any sediment layer. Large sample volumes that are required for some analyses will require submerging the beaker several times to obtain the appropriate volume. A stainless-steel beaker with pour spout and handle works well. It is easily cleaned and considerably less expensive than Teflon™.

Glass Tubes and Bailers

Liquid samples from open containers, such as 55-gallon drums, may be collected. Bailers also may also be used to collect liquid samples from containers such as drums or tanks. The major disadvantages to using bailers are splash hazards, the need for decontamination of reusable bailers, and the generation of waste when using disposable bailers.

Composite Liquid Waste Samplers

The COLIWASA is designed to permit representative sampling of the complete water column from drums or other containerized liquid media. This type of sampler is used when contaminants of different densities, such as oil and water, are potentially present in the containerized liquid. A typical COLIWASA consists of a 152-cm long by 4-cm ID section of tubing with a neoprene stopper at one end. The stopper is attached to a rod running the length of the tube and terminating with a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sample by raising and lowering the neoprene stopper.

10.0 ANCILLARY DATA COLLECTION

10.1 Hydrolab Datasonde

The Hydrolab Datasonde 3 (DS3) Multiparameter Water Quality Dataloggers may be deployed to measure in-situ water quality and tidal phases in nearby or onsite water bodies. The multi-mode device will measure temperature, pH, dissolved oxygen, conductivity, salinity, depth, and oxidation/reduction potential (redox). Refer to Appendix B for Hydrolab operating procedures and to the zone-specific SAPs for deployment locations.

10.2 Current Meter

A current meter may be deployed with the Hydrolab Datasonde surveyor to aid in physically characterizing the surface water body. The Niskin Winged Current Meter will be deployed with the DS3 approximately 2 feet above the bottom during one of the wettest and one of the driest months of the year (based on historical climatological data). The meter measures current by measuring the angle of tilt of its own housing when suspended from a suitable mooring. The current meter will be operated, calibrated, and maintained according to the manufacturer's specifications. The operating manual for the Niskin Winged Current Meter is included as Appendix C. Alkaline batteries will be used instead of the lithium battery listed in the operating manual.

10.3 Rain Gauge

Rain gauges may be installed near selected sites of interest to document rainfall influence on water level. Rain gauges will be installed according to the manufacturer's specifications. Rain gauges will be read after every rain event or daily, whichever time period is less. A log of these measurements will be maintained.

10.4 Water Level Indicator

The static water level in monitoring wells and the depth of water at each surface water sampling location shall be measured before sample collection. For monitoring wells, an electronic water level indicator will be used. The decontaminated probe will be inserted down the well. A tone will indicate the probe's contact with water. Pinpoint the water level by slowly raising and lowering the probe until the tone is heard consistently below, and not above, a specific point. Water level will be recorded to the nearest 0.01 foot on the Measurement of Groundwater Level Form provided in Figure 10-1 or in the field logbook.

10.5 Secchi Disk

Before collecting surface water samples, measure water clarity at each surface water sampling location. A secchi disk attached to the end of a graduated rope will be lowered into the water. The first depth at which the disk is no longer visible from the surface (or when it touches the bottom) will be recorded in the appropriate field logbook.

10.6 Hydrogeologic Assessment

The objective of the hydrogeologic assessment is to better understand the hydrogeology underlying the site(s). The hydrogeologic assessment will include an elevation survey of newly installed monitoring wells; water level measurements in all onsite monitoring wells and/or adjacent surface water bodies; and, as appropriate, multi-well pumping tests and slug tests on newly installed or existing monitoring wells.

All newly installed and existing monitoring wells will be surveyed during the cadastral or geodetic survey. Each well will be referenced to a common datum for elevation in accordance with NAD 1983 standards. In addition, staff gauges will be placed in the surrounding surface water bodies and surveyed relative to the same benchmark.

Static water levels will at a minimum be measured in all monitoring wells located on NAVBASE during quarterly groundwater sampling events. Water levels will be collected at both high and low tides and used to determine groundwater elevations for determining groundwater flow direction and calculating of the hydraulic gradient. Groundwater data will be input into a Geographic Information Systems (GIS) data management program to facilitate evaluating

Figure 10-1

Measurement of Groundwater Level Form

MEASUREMENT OF GROUNDWATER LEVELS									
PROJECT NO:					DATE:				
OWNER:					BY:				
LOCATION:					METHOD OF MEASUREMENT:				
Well Number	Time	Reference Point	Elevation of Reference	Depth to Product (feet)	Depth to Water (feet)	Water Elevation	Product Thickness	Adjusted Water Elevation	Notes

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groundwater flow on both a zone- and base-wide scale. As appropriate, and especially for low-yield wells, slug tests will be conducted. Falling-head and/or rising-head slug tests may be conducted using electronic data loggers according to procedures provided below.

10.6.1 Slug Testing

Slug testing rapidly and easily estimates aquifer conductivity and transmissivity, and is superior to pump testing in most remedial investigations because it produces little or no contaminated water requiring containment and disposal.

General Procedures for Performing a Slug Test

1. Insert a decontaminated pressure transducer, calibrated to an electronic data logger, to an appropriate depth in the well to be tested.
2. Add or remove a known volume to (or from) the well or piezometer to create a rapid rise (or fall) in water level. In most cases, a stainless-steel or Teflon™ cylinder of known volume will be used.
3. Measure the rate of water-level recovery using the pressure transducer and data logger.
4. Graph data, in depth-time pairs, and determine hydraulic conductivity and aquifer transmissivity. A commercially available aquifer analysis will be used. Specific analytical techniques and assumptions made by the hydrogeologist will be provided in the zone-specific SAP and/or the report.

Procedures for Falling-Head Slug Test

Before Slug Testing:

1. Put on personal protective clothing, as specified in the zone-specific CHASP.
2. Place plastic sheeting around the wellhead. Arrange needed equipment and decontaminated materials on the sheet.
3. Open the locking and vented caps and inspect the wellhead. Note in particular the surveyed reference mark's conditions, if any.

4. Measure and record the static water level and the depth to bottom of the well. Record these data in the appropriate logbook.

During Slug Testing:

5. Check calibration of the pressure transducer at two different depths in the well. Check depths should be widely separated. Leave the transducer at the lower check point.
6. Rapidly insert slug (stainless-steel or Teflon™ cylinder) into the water.
7. Using the data recorder, record fall in water level vs. time.
8. Continue recording depth-time data until the well has recovered to nearly static water level. When using data recorders, check and record the reading every few minutes to ensure data are being properly recorded.

After Slug Testing:

9. Record the time of test completion in the logbook. If a data recorder with random access memory (RAM) or erasable programmable read only memory (EPROM) was used, record the file name used.
10. Decontaminate all equipment according to the guidelines in Section 15 of this CSAP. Clean up the site, and close and lock the well before leaving. Place contaminated plastic sheeting and disposable protective clothing in the designated drum for future disposal by the Navy in accordance with Section 16 of this CSAP.

    NOTE: Both rising- and falling-head slug tests may be carried out in the same operation by first measuring the rate of water-level fall immediately after slug insertion, then measuring the rate of water-level rise after slug withdrawal. Be sure the well has recovered to static water level before conducting the rising-head slug test.

Procedures for Rising-Head Slug Test

If the monitoring well screen brackets the water table, the rising-head slug test generally will be more representative than the falling-head.

Before Slug Testing:

1. Lower a decontaminated slug (stainless-steel cylinder) of known volume into the well until it is fully submerged. Allow the well to re-equilibrate to static water level.
2. Turn on the data recorder, if used, or verify the static water level has been re-established with a water-level meter.

During Slug Testing:

3. Withdraw slug quickly, avoiding surging.
4. Using a data logger, record the rise in water level vs time.
5. Continue recording depth-time data until the well has recovered to nearly static water level. When using data recorders, check and record readings every few minutes to ensure data are being properly recorded.
6. Record time of test completion in the field logbook. If a data recorder with RAM or EPROM memory was used, record the file name used.

After Slug Testing:

7. Decontaminate all equipment. Clean up the site, and close and lock the well before leaving. Place any contaminated plastic sheeting and disposable protective clothing in a designated drum for disposal by the Navy in accordance with Section 16 of this CSAP.

Restrictions/Limitations

In wells where the static water level and those induced during testing are above the top of the screened or open hole interval, both rising-head and falling-head tests should be conducted to check results.

Quality Control Requirements for Slug Tests

- A pressure transducer and data logger, or strip chart recorder, must be used to perform these tests.
- Slug tests shall be performed after groundwater sampling to minimize contamination.
- All equipment must be decontaminated before each test.

10.6.2 Pumping Tests

Multi-Well Pumping Tests

In general, the investigation will contain slug test results and interpretations, which will be sufficient for site characterization. If evaluation shows groundwater remediation is required and the aquifer test data are insufficient for remedial design, then the data will be used to design a high-volume test for remedial design purposes. Multi-well pumping tests will be conducted by withdrawing groundwater at a constant, known rate from a designated production well. If the well can sustain enough discharge to adequately stress the aquifer, then aquifer tests will be performed in the unconfined surficial zone for a minimum of 72 hours (48 hours of discharge, 24 hours of recharge). A flow meter will determine if the pumping rate remains constant. During multi-well tests, water levels will be measured simultaneously in designated adjacent monitoring wells. In general, the tests will be based upon zone-specific objectives (e.g., steady state conditions or boundary conditions). Water-level recovery in production and monitoring wells will be monitored after the pump is turned off until the water recovers to its original level (less residual drawdown). Drawdown and recovery data from each pumping test will be plotted to produce time vs. drawdown graphs, which will be used to calculate hydraulic conductivity and transmissivity, and to determine the hydraulic connection between zones. Specific analytical techniques and assumptions used by the hydrogeologist will be provided in the zone-specific SAP, the report, and/or appropriate deliverable documents.

10.6.3 Tidal Influence Study

At selected locations, the influence of tides on static groundwater levels will be evaluated. Monitoring wells oriented both perpendicular and parallel at various distances to the shoreline will be selected for study.

1. Lower a decontaminated pressure transducer or Well Sentinel into the well until it is fully submerged. Allow the well to re-equilibrate to static water level.
2. Turn on the data recorder, if used. The data recorder or Well Sentinel will record the rise and fall in water level vs. time at selected time intervals for the designated study period. The time intervals and the sampling period will be designated in the zone-specific SAP.
3. Record test completion time in the field logbook. If a data recorder with RAM or EPROM memory was used, record the file name. If a Well Sentinel was used, download the data into a computer.
4. Decontaminate all equipment. Clean up the site, and close and lock the well before leaving. Place any contaminated plastic sheeting and disposable protective clothing in a designated drum for disposal by the Navy accordance with Section 16 of this CSAP.

10.7 Radioactivity Screening - Gamma Sources

Charleston Naval Shipyard (CNS) will perform detailed radiological surveys at all locations within the shipyard having any potential for radioactivity and document radioactivity levels which are consistent with naturally occurring background. Additionally, the Navy will be performing detailed radiological surveys at certain sites on NAVBASE. This information may be independently verified by the USEPA and SCDHEC. If practical, sampling should not proceed at any sampling point within the shipyard, or at NAVBASE sites mentioned above until applicable Navy radiological verification surveys have been completed at that sampling point. These surveys will be described in separate workplans and reports. This procedure provides guidance for gamma screening at locations where samples will be collected for determining RCRA remediation actions required. Where it is necessary to proceed with RCRA sampling in advance of planned surveys, in locations specifically designated as having some potential for radioactivity not yet surveyed by the Navy, gamma screening will be conducted in accordance with this section. Upon completion of the detailed surveys, gamma screening will only be required prior to taking samples from any areas specifically designated as having a potential for radioactivity. The purpose of the screening is to identify any sample location where the radioactivity level exceeds 50 microroentgens per hour (μR/hr) and warrants taking precautions during sample collection and analyses. The action level of 50 μR/hr corresponds to those permissible for the general public by the applicable Code of Federal Regulations, i.e. Title 10 or 40, or State regulations.

Equipment Required

- Ludlum Model 3 survey meter
- Ludlum Model 44-5 gamma scintillation probe; 1-inch X 1 inch sodium iodide (NaI); and
- Cesium-137 check source

Radiation Screening Setup:

Check the equipment for proper condition and response to the Cesium-137 check source in accordance with the manufacturer's technical manual and operating instructions. The checks shall be at least daily prior to use and while in use in accordance with the manufacturer's technical manual and operating instructions.

Screening:

Prior to initiation of field activities, obtain concurrence from the shipyard and NAVFAC BRAC Environmental Coordinators (BEC) representatives on the specific locations for which to be gamma surveys are proposed to be taken. Prior to taking samples perform a gamma radiation reading at the ground surface at each designated sampling point. All uR/hr readings shall be documented and independently verified in writing as accurately recorded for each location. If the gamma radiation level at any location is greater than 50 uR/hr in the area do not proceed with taking the sample. In this case, notify the task order manager immediately for further direction. The task order manager will promptly notify both the CNS and NAVFAC BEC representatives, to identify the causes of the deviation from expected background and whether further action is necessary (e.g. radiological precautions necessary for sample collection or analyses). For sites specifically designated as having a potential for radioactivity below surface (e.g. any landfill area), as core samples are taken, gamma survey all portions of the samples in accordance with this section taking standard precautions to avoid direct personnel contact with the samples. If the gamma radiation level on any core sample is greater than 50 uR/hr, discontinue sampling operations. Handle the sample and exposed sampling equipment surfaces as potentially radioactive pending further evaluation. Notify the task order manager immediately for further direction. The task order manager will promptly notify the CNS and NAVFAC BEC representative for further direction as discussed above.

11.0 MANAGING SAMPLES

Samples will be managed in accordance with Section 4.2 of the ESDSOPQAM, included in Volume V of the RFI Work Plan.

11.1 Sample Containers, Preservatives, Holding Times

Appendix D provides information on sample container type and size, preservation requirements, and holding times. The appropriate number of pre-cleaned sample containers, preservatives, and trip blank samples will be obtained from a NEESA-approved laboratory. Stainless-steel sampling liners, which may be used to collect soil samples, will be obtained from the manufacturer and decontaminated in the field before use. Heterotrophic plate count sampling will be conducted with sterile containers and scoops provided by the laboratory.

11.2 Sample Preservation

Samples will be chemically preserved in accordance with the guidelines presented in Section 4.2.7 of the ESDSOPQAM. All samples requiring chemical preservation will be prepreserved either before sample collection or immediately after collection in the field.

In accordance with the ESDSOPQAM the following samples will not be preserved:

- Samples collected within a hazardous waste site thought to be highly contaminated with toxic materials, as well as samples collected from source areas (i.e., barrels, drums, closed containers, or spillage).
- Samples with extremely high or low pH.
- Samples that may generate dangerous gases if preserved.

These procedures will be followed when preserving samples:

1. Ensure that the samples are not over-preserved because courier services may consider them dangerous goods requiring shipment in accordance with International Air Transport

Association (IATA) Dangerous Goods Regulations. As a general rule, four drops of acid will preserve a 40-ml VOA sample and 40 drops of acid will preserve a 1-liter bottle.

2. When testing sample pH, pour a small aliquot of the sample over a piece of pH paper. Place the pH paper into the separate container to determine the pH.
3. If the free chlorine test is positive (i.e., blue color change on the KI paper), preserve the cyanide sample using the following procedures:
   - Add a few crystals of ascorbic acid to the sample. Mix thoroughly.
   - Retest for free chlorine. If the test is positive, continue adding ascorbic acid until the result is negative.
   - When it is negative, add a few crystals of additional ascorbic acid crystals.
   - Add sodium hydroxide (NaOH) to the cyanide sample until the pH is >12.
   - Properly document the sample preservation on the sample label and the chain-of-custody form.
4. If the sulfide test is positive (i.e., bluish-black color change on the lead acetate paper), preserve the cyanide sample following the procedures listed below:
   - Add a small amount of lead carbonate to the sample. Mix thoroughly.
   - Continue the procedure until a precipitate is formed.
   - Filter the sample using a 0.45-micron filter.
   - Add NaOH to the filtered sample until the pH is >12.
   - Properly document the sample preservation on the sample label and the chain-of-custody form.

11.3 Packaging Samples for Shipment

All samples will be packed for shipment according to Appendix, C Section C.3 of the ESDSOPQAM to avoid breakage and prevent cross-contamination.

Sample Packaging Procedures

1. Select a cooler in good condition. Seal the drain plug on the inside and outside of the cooler with tape to prevent leakage.
2. Line the cooler with a large plastic bag.

While Packaging Samples

1. Place one sample container in one sealable plastic bag. VOA vials may be bagged together.
2. To prevent breakage, either:
   - Wrap samples in bubble-wrap packing material. Seal bubble wrap around the containers with tape. Bubble wrap is not required for plastic containers, but take care when packing the coolers so containers do not directly touch each other; OR
   - Place 2 to 4 inches of inert packing material (i.e., vermiculite or cellulose insulation) on bottom of the cooler. Place the bagged containers inside the cooler so the bottles do not touch. Completely fill any remaining space with inert packing material.
3. Include a temperature blank or temperature strip in each sample cooler.
4. Fasten the top of the large plastic bag with tape.
5. Place double-bagged ice inside cooler to preserve the samples to 4°C.
6. Place a chain-of-custody record describing the contents of each cooler in a sealable plastic bag and place it inside each cooler.
7. Seal the cooler with tape and custody seals so it cannot be opened without breaking the seal.

Labeling the Package

1. Clearly print "This End Up" or "This Side Up" on top of the cooler, and place upward pointing arrows on sides of the cooler.
2. Mark cooler with the addresses of both shipper and receiver.
3. If more than one cooler is to be shipped, mark with the sequential cooler number and the total number of coolers (e.g., 1 of 3, 2 of 3, and 3 of 3).

11.4 Sample Labeling

Section 3 of the ESDSOPQAM provides general instructions on labeling samples. Labels will be affixed to each sample container. A sample label is provided in Figure 11-1. Labels will include site, sample identification, collection time and date, method of preservation, sampler identification, and the analyses to be conducted.

Figure 11-1
Sample Label

A Joint Venture for Professional Services **EnSafe/Allen & Hoshall** (901) 383-9115	
Site:	Naval Base Charleston
Sample Number:	
Preservative:	4°C
Analysis:	
Date:	
Time:	
Sampler:	

Sample Number: Assign the sample identification number according to the following format and guidelines:

Format: *X X X X / 1 2 3 4 5 6 7 8 9 0*

XXXX/ — This is a prefix that correlates all samples within a specific project. The prefix is not part of the actual sample identification. All samples collected as part of the NAVBASE investigation will use the prefix "NBC/".

Field Samples:

1 2 3 — The first three digits are for the site where the sample was collected: sites, SWMUs, plumes, buildings, background, etc.

4 — This digit will represent the matrix of the sample. In order to keep the data consistent and facilitate data management, the following master list of abbreviations for common matrices will be used when applicable:

S — soil (surface, borings, and trenches)
C — soil duplicate sample
M — sediment (settled, fluid-borne solid)
N — sediment duplicate
G — groundwater
H — groundwater duplicate sample
W — surface water
R — surface water duplicate sample
U — sludge
Y — sludge duplicate
A — air
Z — liquid waste
V — solid waste

5 6 7 8 — These four digits designate the sampling location: boring or well number, sampling station, trench number, existing well identification, etc.

9 0 — The final two digits represent the sample-specific identification: depth to the nearest foot, depth interval, serial number for water samples, etc.

QC samples:

1 2 3 — The first three digits are for the site where the sample was collected, as above.

4	—	This digit will represent the type of QC sample. Again, in order to keep the data consistent and facilitate data management, the master list of abbreviations for commonly collected QC samples below will be used when applicable: K — MS sample X — MSD sample T — trip blank E — equipment rinsate blank D — deionized water system blank P — potable water blank F — field blank L — filter blank B — USEPA blind spike sample 2 — cement blank 3 — drilling mud 4 — grout blank 5 — bentonite blank 6 — sand blank
5 6 7 8	—	These four digits correlate the QC sample with the field samples associated with it. A simple way to accomplish this is to use the sampling location, for example the boring or well number, of a sample collected on the same day as the QC sample. This also will aid in keeping the QC samples blind to the laboratory.
9 0	—	The final two digits are the serial number for the QC samples. For example, the first rinsate blank collected at a particular site will have the serial number "01," the second rinsate will be "02," etc.

Sample Numbering Guidelines:

- This sample-numbering system uses 10 digits for each sample number. All 10 digits must be used. A master list of sample matrix and QC sample abbreviations is supplied above. Any abbreviations may be used for job site and sample locations, but they must fit into the sample number format. All spaces in the sample number format must be filled and no extra characters included. If all of the spaces are not necessary for a sample identification, zeroes will be used as space-fillers.

- Even though the format for sample numbers is standardized, the system still requires planning on the part of the project or site manager to ensure that every sample has a *unique* number. For example, if multiple sampling events will take place at the same site, this information should be incorporated into the site or sample location abbreviations for samples collected there.
- Define site and sampling location abbreviations as much as possible before starting the sampling event. When necessary, consult the well inventory and sample logbook before assigning new sample numbers. This will reduce the possibility of duplicating abbreviations as sample numbers.
- Samples to be used for MS/MSD analyses will be collected in triplicate to ensure that the analytical laboratory receives sufficient volume for the analyses. The extra sample aliquots will have -MS and -MSD added to the end of the sample number.
- The letters I and O and the numbers 1 and 0 are not used as the matrix/QC digit because they are easily confused on chains-of-custody and sample labels.
- The master abbreviation lists cover only routinely collected QC samples. Some sites may necessitate collecting uncommon sample matrices (i.e., animal or plant tissue samples, wipe sampling, building materials, etc.). These situations will require using a customized matrix and QC sample abbreviation list. When custom codes are necessary, all matrix codes will be defined and documented in the sample logbook and associated field logbook. These custom codes will be carefully selected to avoid confusion with existing sample numbers.
- If multiple soil samples from a trench are to be collected at the same depth, note each sampling location in the field logbook and incorporate both the trench number and sampling location into the sample identification as digits *5678*.
- If a project requires collecting samples for total and dissolved constituent analyses, set up site or sample location identifiers indicating which samples are filtered and which are not.

Completing the Sample Label and Correcting Errors:

All information except date, time, and sample collector's signature will be preprinted on the labels. The remaining information will be recorded clearly on the label in non-erasable, waterproof black ink. Errors will be corrected on the sample label by marking through with a single line, initialing the error, and then recording the correct information.

11.5 Sample Custody

Sample custody or possession will be traceable from the time the sample is collected to its delivery at the analytical laboratory. Refer to Section 3.3 of the ESDSOPQAM for general instructions on maintaining chain-of-custody. Exceptions are outlined below.

Maintaining Field Custody

1. After collecting samples, label and seal the sample jar with a custody seal (see Figure 11-2).
2. Affix the seal so samples cannot be opened without breaking.
3. The sampler must sign and date the seal.

Chain-of-Custody Record

The chain-of-custody form will be used to record custody of the samples. An example of the chain-of-custody form is provided in Figure 11-3. Record the necessary information on the chain-of-custody clearly in non-erasable, waterproof, black ink. Use zeros and sevens with slashes through them to avoid confusion with O's and I's. Correct errors on the chain-of-custody by marking through with a single line. Initial the error and then record the correct information. The following information will be recorded in the appropriate spaces on the form.

Information about EnSafe/Allen & Hoshall:

- Client name (E/A&H) and address of E/A&H.
- Project Name/Number (Naval Base Charleston / Control Task Order [CTO] Number).

NAVY CLEAN
ENSAFE/ALLEN & HOSHALL

ENSAFE/ALLEN & HOSHALL
5720 SUMMER TREES DR. SUITE 8
MEMPHIS, TENNESSEE 38134
(901) 383-9115
OFFICIAL SAMPLE SEAL

SAMPLE #	DATE:
SIGNATURE:	
PRINT NAME & TITLE:	

FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 11-2
CUSTODY SEAL

DWG DATE: 08/08/94 | DWG NAME: 029SECSL

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NAVY CLEAN

ENSAFE/ALLEN & HOSHALL
(901) 383-9115

CHAIN OF CUSTODY RECORD

PAGE ________ OF ________

CLIENT ______________________ PROJECT MANAGER ______________________

ADDRESS ______________________ TELEPHONE NO. ______________________

PROJECT NAME/NUMBER ______________________ FAX. NO. ______________________

MEDIA STATUS: (A, B, OR C) ______________________ SAMPLERS: (SIGNATURE) ______________________

FIELD SAMPLE NUMBER	DATE	TIME	SAMPLE TYPE	TYPE/SIZE OF CONTAINER	PRESERVATION		NO. OF CONTAINERS	ANALYSIS REQUIRED							REMARKS
					TEMP.	CHEMICAL									

RELINQUISHED BY:	DATE / TIME	RECEIVED BY	DATE / TIME	RELINQUISHED BY:	DATE / TIME	RECEIVED BY	DATE / TIME
SIGNATURE ________ PRINTED ________ COMPANY ________ REASON ________	DATE TIME	SIGNATURE ________ PRINTED ________ COMPANY ________ REASON ________	DATE TIME	SIGNATURE ________ PRINTED ________ COMPANY ________ REASON ________	DATE TIME	SIGNATURE ________ PRINTED ________ COMPANY ________ REASON ________	DATE TIME

METHOD OF SHIPMENT: ______________

SHIPMENT NO. ______________

SPECIAL INSTRUCTION: ______________

COMMENTS: ______________________

AFTER ANALYSIS, SAMPLES ARE TO BE:
- ☐ DISPOSED OF (ADDITIONAL FEE)
- ☐ STORED (90 DAYS MAX)
- ☐ STORED OVER 90 DAYS (ADDITIONAL FEE)
- ☐ RETURNED TO CUSTOMER

CHANCUST

FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 11-3
CHAIN-OF-CUSTODY RECORD

DWG DATE: 08/08/94 | DWG NAME: 029COCR

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- Project Manager's Name.
- Signature of Sampler(s).

Information about the Sample:

- Field sample identification (as described in previous section).
- Date and time of collection (24-hour clock).
- Type of sample.
- Type and size of sample containers.
- Preservation temperature and chemical.
- Number of sample containers per sample.
- Type of laboratory analysis required.
- Comments such as "strong odor" etc. go in the remarks section.
- Samples to be used for MS/MSD will be indicated in the "Remarks" section.

Information about Transfer, Shipment and Disposal:

- When sample custody is transferred, document it in the appropriate section of the form.
- The person relinquishing custody must print his or her name, company name, reason for the transfer, date, time, and signature on the form.
- The method of shipment and the air-bill number of the shipment will be noted on the chain-of-custody form.
- During shipment, the chain-of-custody form must be sealed in a plastic bag and secured inside the shipping cooler.
- Note any special instructions (e.g., priority turnaround) or comments in the appropriate section of the chain-of-custody and discuss them with the laboratory before collection and shipment.
- Note sample disposal or storage instructions after completing laboratory analysis.

11.6 Chain-of-Custody Transfer

Refer to Section 3.3.5 of the ESDSOPQAM for general instructions on transferring custody and shipping of samples. Specifics are listed below.

Transferring Custody

1. Record the air-bill number in the appropriate section on the chain-of-custody record and in the field notebook. Seal the chain-of-custody form in a plastic bag and place it inside the shipping cooler before closing.
2. Secure shipping coolers with tape and place a custody seal on each side of the cooler's exterior to prevent opening without breaking the seal.
3. Ship samples overnight to the selected analytical laboratory.
4. When relinquishing custody to a shipper, advise the laboratory of any time constraints on analysis. Notify the laboratory as early in the week as possible regarding samples intended for Saturday delivery.

Laboratory Sample Receipt Procedures

1. A sample custodian accepts custody of the shipped samples from the carrier and enters data about the package into a receipt log, including the status of the coolers' custody seals.
2. The laboratory sample custodian opens the shipping coolers, checks the contents, logs in the samples, and verifies that the information on the chain-of-custody agrees with samples received.
3. The custodian records information such as shipment, pickup, and courier on the "Remarks" section of the chain-of-custody record. The custodian also documents temperature of the cooler by checking the temperature blank or strip, as well as the general condition of sample containers.
4. The analyst verifies sample preservation before extraction, digestion, or analysis and records pH.

5. If samples are improperly preserved, the Laboratory Quality Assurance Coordinator (LQAC) documents this fact, along with the sample identification and other pertinent information, and notifies the task order manager and site manager. All other QA/QC discrepancies are handled similarly and must be documented as an out-of-control event with the corrective action taken.

12.0 ANALYSIS

12.1 Field Parameters

The QA/QC objectives for parameters to be measured in the filed are presented in Table 12-1. Precision and accuracy targets for pH, temperature, and conductivity measurements are those specified by the USEPA ESDSOPQAM. QA/QC targets for other measurements are based on the manufacturer's specifications pertaining to precision and accuracy of the instrument.

Table 12-1
Field Measurements

Field Measurements	Matrix	Precision	Accuracy	Completeness
pH	Water	± 0.5 Std. Units.	± 0.2 Std. Units	90%
Temperature	Water	± 1.0° C	± 0.2° C	90%
Specific Conductivity	Water	± 10%	± 1% of full scale	90%
Salinity	Water	± 2.0 ppt	± 1.0 ppt	90%
PID/FID	Air	± 10 ppm	± 2 ppm	90%
Static Water Level	Water	± 0.01 ft.	± 0.05 ft.	90%
Redox	Water	**	± 20 mV	90%
Dissolved Oxygen	Water	**	± 2 mg/l	90%
Turbidity	Water	0.01 NTU	0.1 NTU	90%
Wellhead Points	Spatial	± 5%	± 0.1 ft.	90%
	Vertical	± 0.05 feet	± 0.01 ft.	90%

Field Measurement References:

- **pH, Temperature, and Specific Conductivity:** Methods for Chemical Analysis of Water and Wastes, USEPA-600/4/79-020, Revised March 1983.
- **Salinity:** Manufacturer's SOP for salinity measurement.
- **PID/FID:** Manufacturer's SOP for operation of Photovac MicroTIP, Foxboro OVA, and HNu.
- **Water Level, Redox, Dissolved Oxygen:** Manufacturer's SOP for the Hydrolab Datasonde.
  ** SOP's precision values of these parameters = one month's stability of accuracy.
- **Wellhead Points:** Standard Land Surveying Methods in accordance with National Geodetic Survey.
- **Turbidity:** Manufacturer's SOP for turbidity meter.

Calibrating and Standardizing Equipment

Field measurement instruments will be calibrated at least twice daily (before use and at the end of the day) according to the manufacturer's specifications. Instruments also may be calibrated during the day if field personnel consider it necessary. Tracing each standard to National Institute of Standards and Technology (NIST) will be based upon the forms and product-specific information provided by the standard manufacturer/supplier. Instrument calibration will be recorded in the field logbook or calibration forms, and calibration procedures and calculations will be recorded on the calibration log forms in Figures 12-1 to 12-3.

Calibrating and Standardizing Temperature Probes

1. Initially, calibrate all thermometers against a NIST-certified thermometer or one traced to National Bureau of Standards (NBS) certification. Glass mercury-filled thermometers will not be used.
2. Test temperature probes for calibration quarterly by checking the unit against a NIST-certified thermometer. If values do not fall within specified ranges listed in Table 12-1, the probe will not be used and will be returned to the manufacturer for service.

Calibrating and Standardizing pH Meters

1. Check the pH meter before use for any mechanical or electrical failures, weak batteries, and cracked or fouled electrodes.
2. Standardize the pH meter before use each day in the field using a 2-point calibration. The meter slope will be checked initially using pH 4, 7, or 10 buffer solutions, depending on the expected pH value of the samples to be analyzed. A meter slope outside the range of 85 to 115 percent indicates meter or probe failure. The calibration check process will be repeated between sampling locations using one of two initial buffer solutions. Record the calibration in the field logbook, and all calibration procedures and calculations on the calibration log in Figure 12-1.

Figure 12-1
Calibration Log — pH Meter
Naval Base Charleston — Charleston, South Carolina

pH Meter:

Model: ____________________ Date/Time: ________________

Serial Number: _____________ Checked by: _________________

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	___	___
Is the battery charge acceptable?	___	___
Is the liquid crystal display (LCD) functioning properly?	___	___
Is the probe filled with proper solution?	___	___
Are there any visible cracks or problems with the probe?	___	___

Two- or Three-point Calibration

	Reading	**Lot #**	**Expiration Date**
Buffer 4.0:	_________	_________	_________
Buffer 7.0:	_________	_________	_________
Buffer 10.0:	_________	_________	_________
Initial Slope:	___________		

Remarks:

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Figure 12-2
Calibration Log — Conductivity Meter
Naval Base Charleston — Charleston, South Carolina

Conductivity Meter

Model: ____________________ Date/Time: ____________

Serial Number: ______________ Checked by: ___________

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	___	___
Is the battery charge acceptable?	___	___
Is the liquid crystal display (LCD) functioning properly?	___	___
Is the conductivity cell clean?	___	___
Are there any visible cracks or problems with the probe?	___	___

Conductivity Calibration Standards:

Source:__________ Date of Receipt:________ Lot #/Expiration:____________

Two-point Calibration

		NIST Lot #
100 μmhos/cm Solution:	__________	_________
1000 μmhos/cm Solution:	__________	_________

Temperature: __________ Instrument internal calibration: __________

Remarks:

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Figure 12-3
Calibration Log — PID/FID/OVA Meter
Naval Base Charleston — Charleston, South Carolina

PID/FID/OVA Meter:

Model: ________________   Date/Time: ___________

Serial Number: __________   Checked by: ___________

Instrument Checklist:

	YES	NO
Is the instrument clean and in good condition?	___	___
Is the battery charge acceptable?	___	___
Is the readout display functioning properly?	___	___
Are there any visible cracks or problems with the meter?	___	___
Does ultraviolet lamp window or dust filter need cleaning?	___	___

PID/FID/OVA Calibration Standards:

Span Gas Type/Source: ___________________

Date of Receipt: ___________________

Lot #/Expiration: ___________________

Remarks:

This left blank intentionally.

Calibrating and Standardizing Specific Conductivity

1. Refer to the designated cell constant of the conductivity cell in the manufacturer's instruction book. Determine the actual cell constant each day before use.
2. Use a conductivity calibration solution to check the cell constant. If the values obtained during the check are within specification, any measured deviation will be used to extrapolate a more accurate sample reading as outlined in the manufacturer's instructions. If the check values are out of specification, the cell will be returned to the manufacturer for repair.
3. Check each conductivity meter before use to ensure the probe is intact, the batteries are sufficiently charged, and the cell is clean. Calibration procedures entail checking the conductivity cell with one potassium chloride standard in the expected range of the sample(s) to be collected.
4. If the conductivity meter does not automatically compensate for temperature, manually recalibrate it to account for temperature.
5. Record the calibration in the field logbook, and all calibration procedures and calculations on the calibration log in Figure 12-2.

Calibrating and Standardizing Photo/Flame Ionization Detectors and Organic Vapor Analyzers (OVA)

1. Calibrate the PID/FID/OVA quarterly using the kit provided by the manufacturer. Alternatively, rented instruments will be returned to the manufacturer/rental company for quarterly calibration.
2. Calibrate each PID/FID/OVA both before use and at the end of the day with the calibration span gas specified by the manufacturer.
3. Record background readings at the site.
4. Clean the instrument's exterior quarterly by wiping with a damp cloth, using a mild detergent when necessary.
5. Correct all field readings for ambient background readings by subtracting the measured

background reading from the field reading. ***Under no circumstances will the meter be zeroed based on ambient conditions in the AOC.***

6. Recharge the instrument's battery when the low-battery indicator appears. The instrument should be allowed to fully discharge before fully recharging. This will maximize its operating time.
7. Record the calibration in the field logbook, and all calibration procedures and calculations on the calibration log in Figure 12-3.

Quality Assurance Targets for Precision and Accuracy in the Field

Precision and accuracy targets for pH, temperature, and specific conductivity measurements are specified in Section 6 of the ESDSOPQAM and are provided in Table 12-1. Quality Assurance (QA) targets for other measurements are based on manufacturer's information pertaining to the precision and accuracy of the associated instruments.

12.2 Laboratory Analysis

Parameters and Analytical Methods to be Used:

Parameters and analytical methods are presented in Appendix D. Samples will be analyzed in accordance with the applicable methods as outlined in *Test Methods for Evaluation of Solid Waste (Physical/Chemical Methods), SW-846*, Third Edition, September 1986. Additional analytical methods for potentially analyzed parameters not included in the SW-846 analyses are listed below.

Additional Methods for Laboratory Analysis:

- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, 40 Code of Federal Regulations (CFR) Appendix A to Part 136, July 1987.
- *Methods for Chemical Analysis of Water and Wastes*, USEPA-600/4-79-020, Revised March 1983.The analytical laboratory will calibrate instruments according to protocols of the specified method to be performed and with the laboratory calibration procedures outlined in ESDLOPQCM, included in Volume V of the RFI Work Plan.

QA Targets for Laboratory Precision and Accuracy

Project QA objectives for analytical parameters for soil and groundwater are stipulated in the respective analytical methods and as determined by the analytical laboratory's historical data quality evaluation for these methods. The NEESA laboratory approval process ensures laboratory method QA/QC standards are appropriate to meet goals for intended data uses. General QA goals for these methods are presented in Tables 12-2 and 12-3.

The contract laboratories' QAPs are included in Volume V of the RFI Work Plan for EPA approval. If the services of additional laboratories are needed for this investigation, advance notice will be given and the laboratories' QAPs will be made available for USEPA and NEESA review and approval.

Table 12-2
Metals Analyses Data QA Objectives
Matrix Spikes/Duplicate Analyses

Compound (Metal)	Precision* (RPD)	Accuracy (% Spike Recovery)
Aluminum	± 20	80-120
Antimony	± 20	80-120
Arsenic	± 20	80-120
Barium	± 20	80-120
Beryllium	± 20	80-120
Cadmium	± 20	80-120
Calcium	± 20	80-120
Chromium	± 20	80-120
Cobalt	± 20	80-120
Copper	± 20	80-120
Iron	± 20	80-120
Lead	± 20	80-120
Magnesium	± 20	80-120
Manganese	± 20	80-120

Table 12-2
Metals Analyses Data QA Objectives
Matrix Spikes/Duplicate Analyses

Compound (Metal)	Precision* (RPD)	Accuracy (% Spike Recovery)
Mercury	± 20	80-120
Nickel	± 20	80-120
Potassium	± 20	80-120
Selenium	± 20	80-120
Silver	± 20	80-120
Sodium	± 20	80-120
Thallium	± 20	80-120
Tin	± 20	80-120
Vanadium	± 20	80-120
Zinc	± 20	80-120
Cyanide	± 20	80-120

Notes:
RPD - Relative Percent Difference
* — precision limits apply when metal is present at ≥ 10 times the instrument detection limit (IDL)

Table 12-3
Organic Analyses Data QA Objectives
Matrix Spikes/Matrix Spike Duplicates/Surrogate Spikes

Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
VOA	**Matrix Spikes**				
(8240)	1,1-Dichloroethene	22	59-172	14	61-145
	Trichloroethane	24	62-137	14	71-120
	Chlorobenzene	21	60-133	13	75-130
	Toluene	21	59-139	13	76-125
	Benzene	21	66-142	11	76-127
VOA	**Surrogate Spikes**				
(8240)	Toluene-d_8	—	84-138	—	88-110
	4-Bromofluorobenzene	—	59-113	—	86-115
	1,2-Dichloroethane-d_4	—	70-121	—	76-114

Table 12-3
Organic Analyses Data QA Objectives
Matrix Spikes/Matrix Spike Duplicates/Surrogate Spikes

Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
SVOA	**Matrix Spikes**				
(8270)	1,2,4-Trichlorobenzene	23	38-107	28	39-98
	Acenaphthene	19	31-137	31	46-118
	2,4-Dinitrotoluene	47	28-89	38	24-96
	Pyrene	36	35-142	31	26-127
	N-Nitroso-Di-n-Propylamine	38	41-126	38	41-116
	1,4-Dichlorobenzene	27	28-104	28	36-97
	Pentachlorophenol	47	17-109	50	9-103
	Phenol	35	26-90	42	12-110
	2-Chlorophenol	50	25-102	40	27-123
	4-Chloro-3-Methylphenol	33	26-103	42	23-97
	4-Nitrophenol	50	11-114	50	10-80
SVOA	**Surrogate Spikes**				
(8270)	Nitrobenzene-d_5	—	23-120	—	35-114
	2-Fluorobiphenyl	—	30-115	—	43-116
	p-Terphenyl-d_{14}	—	18-137	—	33-141
	Phenol-d_5	—	24-113	—	10-110
	2-Fluorophenol	—	25-121	—	21-110
	2,4,6-Tribromophenol	—	19-122	—	10-123
Pesticides	**Matrix Spikes**				
(8080)	Lindane (gamma-BHC)	50	46-127	15	56-123
	Heptachlor	31	35-130	20	40-131
	Aldrin	43	34-132	22	40-120
	Dieldrin	38	31-134	18	52-126
	Endrin	45	42-139	21	56-121
	4,4'-DDT	50	23-134	27	38-127
Pesticides	**Surrogate Spikes**				
(8080)	Decachlorobiphenyl	—	60-150*	—	60-150*
	2,4,5,6-Tetrachloro-m-xylene	—	60-150*	—	60-150*

Table 12-3
Organic Analyses Data QA Objectives
Matrix Spikes/Matrix Spike Duplicates/Surrogate Spikes

Fraction	Compound	Soil Precision (RPD)	Soil Accuracy (% Recovery)	Water Precision (RPD)	Water Accuracy (% Recovery)
Herbicides (8150)	**Matrix Spikes**				
	2,4-D	40	40-150	30	40-130
	Silvex	40	40-150	30	40-130
Herbicides (8150)	**Surrogate Spikes**				
	Dicamba	—	50-140	—	50-130

Notes:
VOA = Volatile Organic Analyses
SVOA = Semivolatile Organic Analyses
* = Advisory Limits
— = Not Applicable

13.0 QUALITY ASSURANCE PLAN

13.1 Introduction

This section presents policies, project organization, objectives, and functional activities, along with QA/QC measures intended to achieve the quality assurance goals of the facility investigation to be performed at NAVBASE.

This document is intended to fulfill requirements for ensuring all work will be conducted in accordance with QA/QC protocols and field procedural protocols for environmental monitoring and measurement data as established in the following documents.

Applicable Guidance Documents:

- U.S. Environmental Protection Agency. (February 1991). *Standard Operating Procedures and Quality Assurance Manual.* Athens, Georgia.
- U.S. Environmental Protection Agency. (September 1990). *Laboratory Operations and Quality Control Manual.* Athens, Georgia.
- Naval Energy and Environmental Support Activity. (June 1988) (NEESA 20.2-047B). *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program.* Port Heuneme, California.
- Naval Energy and Environmental Support Activity. (February 1985). (NEESA 20.2-031A) *Groundwater Monitoring Guide.* Port Heuneme, California.
- Southern Division Naval Facilities Engineering Command, Revision 4. (March 1989). SOUTHNAVFACENGCOM *Guidelines for Groundwater Monitoring Well Installation.*
- USEPA. (1986). Office of Solid Waste and Emergency Response (OSWER), *Test Methods for Evaluating Waste — Physical and Chemical Methods*, EPA SW-846. 3rd Edition.
- USEPA. (1986). *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (OSWER-9950.1). Washington, D.C.

- South Carolina Department of Health and Environmental Control. (1985). *South Carolina Well Standards and Regulations*, (R.61-71). Columbia, South Carolina.

Where specific NEESA guidelines do not exist, applicable USEPA and/or SCDHEC guidelines and methods will be applied. The ESDSOPQAM and ESDLOPQCM will take precedence over NEESA guidance where there is a conflict. These regulations are referenced in specific sections of this document where applicable.

Before field investigations begin, a site meeting will be conducted for the Task Order Manager, all field personnel, a representative of the site management, and any subcontractors who will be working onsite to familiarize all parties with the site, discuss the logistics with management, and discuss health and safety procedures. The Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) Engineer in Charge (EIC) and representatives from the SCDHEC and USEPA Region IV will be invited. The investigation will begin upon authorization from the EIC.

13.2 QA/QC Objectives

In general, quality assurance objectives as part of the Navy technical services contract assess and document the precision, accuracy, representativeness, completeness, and comparability of all sampling and analyses performed. Quality criteria are outlined here to assure data obtained during projects is suitable for its intended use, and to meet goals established by NEESA and in the USEPA document, *DQO for Remedial Response Activities Development Process* (March 1987), OSWER Directive 9355.0-7B. NEESA DQO Level B protocol (USEPA Level II) will be used for the physical surveys. At a minimum, soil, surface water, sediment, groundwater, and contaminant quantification investigations will be conducted at NEESA DQO Level C protocol (USEPA Level III). A percentage (to be negotiated with the regulatory agencies involved) of the soil, surface water, sediment, and groundwater samples collected will be submitted in duplicate to the laboratory for analysis with NEESA Level D protocols (USEPA

Level IV) for confirmation purposes. The following discussion presents the project specific level of effort for quality assurance and data quality criteria. Quality control sample collection will follow the frequency presented in Table 13-1.

Table 13-1 Quality Control Sample Collection Frequencies	
Duplicates:	One per 20 water, soil, and soil-gas samples collected
Field Blank:	One per sampling event (week) per source. (Potable Water and Reagent Grade Water—ASTM Type III)
Trip Blank:	One per sample shipping cooler containing VOA samples
Rinsate Blank:	One per week per media; one per 20 soil-gas samples collected
MS/MSD:	One per 20 water and soil samples collected; MS/MSD are to be the same sample used for duplicate analysis
Equipment/Material Blanks:	One sample each of filter pack sand, drilling mud, grout, bentonite pellets, or powder used in well construction per material source/site
Temperature Blank:	One per sample shipping cooler
Preservative Blank:	One at beginning and one at end of all major field investigations (20 samples or more. One at end of small studies.

Notes:
Trip blanks are for volatile organic analysis only.
Preservative blanks are for metals and general inorganics.

13.2.1 Precision

Precision is a measure of the reproducibility of measurements and methods, and is defined for qualitative data as a group of values' variability compared with its average value. To assess the precision of the measurement systems used in this project, duplicates will be obtained and analyzed with the samples collected. Precision, to be used as a criterion for data classification, is calculated as a relative percent difference in analytical outcome between a given sample and corresponding duplicate.

The type of duplicates used will depend on the part of the measurement system to be evaluated for precision. Field-duplicated samples analyzed by the same laboratory will yield information about sampling method precision and matrix homogeneity. Laboratory-duplicated samples give an indication of sample preparation and analytical method precision.

A field duplicate is a sample collected in the field from the exact location as another sample and sent to the laboratory for analysis with the original sample. A laboratory duplicate is prepared in the laboratory and consists of a split from a sample sent there from the field.

13.2.2 Accuracy

The accuracy of an entire measurement system, which is an indication of any bias, is difficult to measure in environmental measurement systems. Sources of error are the sampling process, field and laboratory contamination, preservation, handling, sample matrix, and analysis. The accuracy of a method is an estimate of the difference between the true value and the determined mean value. In the field, methods used for detecting false positive results include the preparation of trip blanks, field blanks, and equipment rinsate blanks. In the laboratory, MS/MSD samples and surrogate spike solutions are used to detect positive and negative bias.

Per NEESA definitions, a field blank consists of sample containers filled in the field with water from each source used for decontamination. Field blanks are prepared, preserved, and stored in the same manner as the samples. The field blank is analyzed along with the field samples for the constituents of interest to check for contamination imparted to the samples by the water source. Samples of the ASTM Type III water and tap water will be collected weekly. Field blanks may also be collected to determine if any contaminants present in the area, such as dust or VOAs from a source other than that being sampled, may impact sample integrity.

Trip blanks will be used to measure volatile constituents. A trip blank consists of a VOA sample vial that is filled with organic-free water in the laboratory and travels unopened with the sample bottles to the field. Trip blanks will be stored unopened with the sample bottles in a contaminant-free area. The trip blank is then shipped back to the laboratory with volatile samples collected in the field. It is opened in the laboratory and analyzed along with the field samples for the volatile constituents of interest. Trip blanks will be submitted to the laboratory with samples for volatile analysis at a frequency of one per shipping container containing VOA samples. If trip blanks are received from the laboratory containing air bubbles (pinhead size or larger), the trip blanks will be discarded and the laboratory contacted.

An equipment rinsate blank is made by taking ASTM Type III water and placing it in contact with the field sampling apparatus (e.g., bailer, pump, stainless-steel split-barrel sampler, Xi-Tech™ sampling sleeve) after decontaminating equipment. The water will be collected in the same type of containers as the other samples, preserved in the same manner, and analyzed for the same parameters of interest. One equipment rinsate blank will be collected each week per sampling media. If sampling occurs in the same sample media using different equipment in the same week (e.g., if soil samples are collected with Xi-Tech™ sampler, split-barrel sampler, and hand auger) a separate rinsate blank will be collected for each piece of sampling apparatus.

MS/MSD samples prepared by the laboratory are useful in assessing the accuracy of the analytical methods, and can detect matrix effects where other sample components interfere with analyzing the chemical(s) of interest. The method of measuring analytical accuracy is percent recovery.

Analytical MS and MSD samples will be performed by the laboratory, typically at a frequency of one MS/MSD pair per 20 samples per matrix. Control limits for laboratory matrix spike recovery are published by USEPA or determined by historical laboratory results. Surrogate spikes, typically prepared from deuterated isomers of selected target compounds and added to each sample, provide an added measure of method accuracy in organic analyses. General precision and accuracy goals for laboratory analytical procedures (NEESA DQO Level C/USEPA DQO Level III) are as previously provided in Tables 12-2 and 12-3. To provide the additional volume needed by the lab for MS and MSD analysis, double the volume for the first sample of each 20 soil, water, and sediment samples.

An equipment/materials blank shall be collected from the materials and liquids to be used in monitoring well construction at each investigation site. These blanks will be analyzed at DQO Level IV.

13.2.3 Representativeness

The goal of this investigation is to delineate the extent of any soil and groundwater contamination and to determine the most appropriate remedial option. Soil and groundwater samples will be properly collected and monitoring well parameters will be measured in accordance with NEESA and USEPA protocols to ensure samples collected during the investigation are representative of the AOC.

13.2.4 Completeness

Completeness goals for this project are set at 90 percent for laboratory analyses. Data completeness is the percentage of total valid tests conducted and the percentage of the total valid tests required in the scope of work.

Completeness goals of field measurements reflect the ability to re-sample immediately, before declaring well stability, and obtaining samples for laboratory analysis. The completeness goals consider unavoidable non-attainment of QA goals during the course of an investigation. Efforts will be made, however, to maintain soil and groundwater data completeness levels above 90 percent for field measurements, if possible.

13.2.5 Comparability

Comparability is assured by using established methods of field sampling by experienced field personnel and laboratory analyses as specified by the ESDSOPQAM and NEESA regulations.

13.3 Organization and Responsibilities

Overall responsibility for projects conducted in accordance with NEESA regulations will be vested in NEESA (or its approved representatives). Therefore, project coordination responsibilities lie with the SOUTHNAVFACENGCOM EIC. The components of the project chain-of-command will be performed as established in NEESA 20.2-047B. Project oversight will be organized along the following lines of authority.

Naval Energy and Environmental Support Activity: NEESA is responsible for ensuring the quality of laboratory analyses performed during the various phases of the Comprehensive Long-Term Environmental Action Navy (CLEAN) is acceptable. NEESA is also responsible for managing the NEESA contract representative (NCR).

Engineer in Charge: The EIC at the engineering field division provides the site information and history, provides logistical assistance, specifies the sites requiring investigation, and reviews results and recommendations.

The EIC is responsible for coordinating procurement, finance, and reports; for ensuring all documents are reviewed by the NCR; for communicating comments from the NCR and other technical review to the subcontractors; and for ensuring the subcontractors address all the comments submitted and take appropriate corrective actions.

NEESA Contract Representative: The NCR is responsible for ensuring each project has appropriate overall QA. The NCR reviews laboratory QA plans and work plans, submits performance sample data, provides field and laboratory audits, and reviews data from the site. The questions from subcontractors and the EIC regarding specific field and laboratory QC practices are directed to the NCR, who also evaluates referee samples.

State or Local Oversight: This CSAP will be submitted to the SCDHEC and the USEPA Region IV for review and approval. Field activities and meetings will be coordinated with these agencies as required.

Investigation Performance: The following individuals or firms will be responsible for the implementing of all work activities.

Engineering Contractor: E/A&H will serve as the engineering contractor for this project. As the engineering contractor, E/A&H is responsible for designing and implementing the Remedial Investigation/Feasibility Study (RI/FS) and preliminary site characterization activities.

Analytical Laboratory**:** The laboratory to be used will be NEESA-approved. SW-846 analytical methods using USEPA Level III protocols and USEPA Level IV protocol will be used by the selected laboratory. The laboratory must adhere to the laboratory requirements in NEESA 20.2-047B and follow the quality assurance/quality control guidance found in the ESDLOPQCM. Where discrepancies between the NEESA and USEPA QA guidelines occur, the USEPA document will take precedence. The laboratory must prepare and submit a laboratory QA plan, analyze and submit the results of proficiency testing, submit to an onsite inspection, and correct any deficiencies cited during the inspection by the NCR.

The laboratory is required to identify a Laboratory QA Coordinator (LQAC) responsible for overall quality assurance. The LQAC must not be responsible for schedule, costs, or personnel other than QA assistants. It is preferred the LQAC report to the laboratory director. The LQAC must have the authority to stop work on projects if QC problems arise affecting the quality of the data produced.

In addition to conforming to all NEESA regulations, all work shall be performed in a manner consistent with the regulations listed below.

Applicable Regulations:

- The National Oil and Hazardous Substances Contingency Plan (NCP), Title 40 CFR, Part 300, as amended.
- Other appropriate federal, state, and local guidelines, rules, regulations, and criteria.

14.0 DATA MANAGEMENT PLAN

This section describes the methods to be used throughout the investigation to document field work and manage collected data.

14.1 Field Documentation

The field project manager will be thoroughly familiar with appropriate documentation procedures. He or she will perform or directly oversee completion of the documents accompanying this investigation. Documentation tasks will be performed on a sample-by-sample or item-by-item basis throughout the day. Sample container labels and chain-of-custody forms will be prepared as completely as possible in advance.

General Field Documentation Procedures

- Complete all documentation in waterproof black ink.
- Mark through corrections with a single line, then date and initial the correction.
- Do not destroy or discard serialized documents, even if they are illegible or inaccurate.
- Maintain voided entries within project files.

Field documentation consists of a master site logbook, one or more site-specific field logbooks, field forms, photographs, sample labels, and chain-of-custody records. This allows detailed data to be recorded in various field logbooks and/or forms and cross-referenced in the site logbook.

Logbooks: Master site and field logbooks provide a daily handwritten record of all field activities at an investigation site. All logbooks must be permanently bound and have a hard cover. Field logbooks must be waterproof. The master site logbook is a master record of all site activities, and entries are usually made at the end of each work day. Field logbooks are detailed daily records kept in real time. A field logbook will be assigned to each site at NAVBASE. Additionally, a sample logbook will be prepared detailing the samples collected each day, but in less detail than the chain-of-custody.

Master Site Logbooks: The master site logbook chronicles all field investigation activities, but without the same level of detail as the field logbook. It delineates conditions and activities occurring on a given day and references the appropriate field logbooks and forms for specific information.

The field project manager completes the master site logbook and signs and dates the end of each page. Pages should not be removed and all partially used pages should be lined through to prevent data entry at a later date. The front of the master site logbook should include the project name and number, name of subcontractor, service client, contract number, and dates of use.

Master Site Logbook Contents:

- List of all field logbooks and brief outline of their required contents.
- Daily temperature, weather conditions, and names and titles of personnel present.
- Levels of personnel protection, and changes if required.
- Name, title, organization, and purpose of any site visitors.
- Brief outline of site activities and references to the appropriate logbook.
- Specific comments on any problems encountered, their resolution, and any impact on the field investigation.
- Any changes and supporting rationale for the change.
- Brief record of all telephone calls and how they affected the investigation.
- Instrument calibration, specifically name(s) of personnel who performed daily calibration.

Field Logbooks: All information required on the cover of the site logbook also must be provided on the cover of each field logbook. In addition, it must list the specific area to which it is assigned. Entries in the field logbook must be made using a 24-hour clock and signed by the responsible person at the bottom of each page. Unused pages or portions of pages not used must be lined out to prevent later entry of additional information. Copies of field logbooks will be made regularly to act as a backup.

Field Logbook Contents:

- Date and time task started and ended; weather conditions, and the names, titles, and organizations of personnel performing the tasks.
- Description of level of PPE and any changes.
- Description of site activities in specific detail or forms used.
- Description of field tests performed and test results.
- Detailed description of samples collected, and any quality control samples collected.
- List of the time, equipment type, and procedures followed for decontamination.
- Record of instrument calibration and any failures with a brief description of repairs and/or replacements.

Sample Logbook: A sample logbook will compile a record of samples collected and shipped (including QA/QC samples), analyses requested, the airbill number of the shipment, and any pertinent information concerning sample status.

Field Data Record Forms: Forms to be used during this investigation include subsurface boring logs, monitoring well construction diagrams, monitoring well development forms, sample records, and additional data as appropriate. Do not leave blank spaces on completed forms. If information on a form does not apply, mark the space "N/A." Complete all forms in the field as the task is performed. Copy forms regularly for backup. Field forms to be used during this investigation are discussed below.

Sample Labels: Attach completed sample labels to each sample container immediately after sample collection. Refer to Section 11.4 of this plan for labeling instructions. Sample label information (at least sample identification number and time of collection) will be recorded in the field logbook as a cross-reference at the time of collection.

Chain-of-Custody Records: The chain-of-custody record will summarize the contents of the shipment, dates, times, sample numbers, number and volume of sample containers; its purpose is to document the transfer of sample custody. See Section 11.6 of this CSAP for chain-of-custody transfer instructions.

Subsurface Boring Logs: Soil boring logs will be maintained by a qualified E/A&H geologist. Lithology will be described from split-barrel samples and auger cuttings using the USCS. Subsurface boring logs will be completed as the boring is advanced. Items to be recorded include materials encountered, depth to water, obvious contamination, and any other necessary information.

Monitoring Well Construction Diagrams: A monitoring well construction diagram will summarize the monitoring well construction. Data to be completed includes location, date drilled, drilling method, well depth, screen location, and general construction data. A general log will also be recorded in the field logbook as a cross-reference. Monitoring well schematics are found in Section 5 of this CSAP.

Photographs: Photographs will be taken of all pertinent field activities as directed by the Field Project Manager. The information listed below will be recorded in the field logbook:

- Date, time, location, and name of photographer.
- Description of photograph and orientation.
- Number of photographs on film roll.

After the film is developed, this information will be written to the back of each photograph.

14.2 Data Deliverables

Hard-copy data shall be provided consistent with the USEPA DQO III and IV requirements, as applicable. USEPA DQO level IV data shall be submitted in a Contract Laboratory Program

(CLP)-like deliverable package. Information and format of the CLP data packages may be obtained from the following documents:

- *USEPA Contract Laboratory Program Statement of Work for Organics Analysis (Document #OLM01.8)*

- *USEPA Contract Laboratory Program Statement of Work for Inorganics Analysis (Document #ILM02.1).*

Disk Deliverables

Each sample delivery group submitted to E/A&H must be accompanied with a diskette containing the following analytical data.

For CLP and non-CLP methods: The analytical data should be submitted on a high-density 5.25-inch or 3.5-inch diskette with the hard copy of the file.

For CLP methods: The USEPA Format A or Agency Standard format is required. This format applies to both organic and inorganic analyses. The format should be modified for handling the 10-digit E/A&H sample identification, plus any lab extensions (i.e., MS, MSD, etc.), OR an identification conversion table must be supplied identifying E/A&H sample identification with converted identification numbers. This file should be provided in ASCII format.

For non-CLP methods: An ASCII fixed-length field format is required; however, other formats may be acceptable, which will be determined on a case-by-case basis.

Each data record should contain the data for one analytical compound and one sample identification, and the following fields:

ASCII FIXED-LENGTH FORMAT

Field	Example	Columns
Case #	26345	1 - 5
Sample Delivery Group (SDG)	CT515	6 - 10
E/A&H Sample Identification	123X7890IM	11 - 20
Lab Extension (MS, MSD, DL, ..)	MSD	21 - 24
Lab Code — 6 digits, representing laboratory	ANALAB	25 - 30
Laboratory Name	ANALYTICAL LABS	31 - 60
Laboratory's Internal Sample Identification #	238396	61 - 72
Matrix (Soil / Water)	Water	73 - 77
Sample Date	04/01/94	78 - 85
Date Sample Was Received by Lab	04/02/94	86 - 93
Date Sample Was Extracted / Prepared	04/04/94	94 - 101
Date Sample Was Analyzed	04/09/94	102 - 109
Chemical Abstracts Services (CAS) #	79016	110 - 119
Compound / Analyte Name	Trichloroethene	120 - 159
Result / Detection Limit	10.0754	160 - 173
Units	UG/KG	174 - 178
Qualifier	U	179 - 186
Method	8240	187 - 196

14.3 Analytical Data Validation

The laboratory's data review will be consistent with the level of effort specified in NEESA 20.2-047B and specific to the laboratory QC level applied. All analytical data will be validated independently of the laboratories analytical data review. Analytical data will be validated by applying the procedures in *National Functional Guidelines for Organic Data Review*, June 1991, and *National Functional Guidelines for Inorganic Data Review*, July 1988, as applicable. Where these guidelines do not apply, data will be validated by applying USEPA precision and accuracy statements for the analytical methods employed. Independent data validation will be conducted on 10 percent of the samples by an independent subcontractor.

14.4 Other Related Data

Other related data will include illustrations, graphs, meeting summaries, audit reports, and laboratory results. This information will be compiled and reviewed for report presentation.

Meeting Summaries, Telephone Conversations, and Notes: These items will be recorded in the field logbooks along with the dates, time, and names of people involved. This information will be available for photocopying if requested. Meetings and conversations with a substantial impact on the project will be described in a memorandum to the project manager.

Illustrations, Computations, and Engineering Data: Original illustrations and graphics will be initialed and dated by the person originating the document. A second person will check for completeness and accuracy. All maps, calculations, and data will be reported or prepared to accepted standards and confidence levels.

Field Change Request Forms: Field change request forms (see Figure 14-1) will be submitted when any deviation from the work plan or SAP is required that will harm the quality of the data

generated, will significantly change the cost of the field effort, will be a major change in the scope of the field effort, or will significantly delay the schedule. Examples of this type of change follow:

- Significantly changing the number of wells,
- Significantly changing the number of sampling points,
- Changing decontamination procedures,
- Changing drilling method or well construction design, and
- Changing sampling methodology.

Information should include the nature of the change, reason for it, and date it will be implemented. These forms will be submitted to the EIC representing the Navy.

14.5 Reports

Progress Reports: Monthly progress reports prepared by the project manager will include the number of samples collected, sites investigated, monitoring wells installed, any deviations from approved field or laboratory procedures, and other appropriate information. These reports will be directed to the EIC.

Zone Reports: The zone RFI report will be written after sampling and validation of all laboratory analyses. The report will consolidate and summarize collected data and document the unit evaluation. An initial draft report will be submitted for comment by the Navy and the USEPA. Where appropriate, comments will be incorporated into the final document.

Final Report: The final RFI report will be written after all the zone reports have been submitted to USEPA for review and comment. The final report will be a comprehensive document that addresses NAVBASE as a whole. The report will consolidate and summarize the results and conclusions presented in each the zone reports.

FIGURE 14-1 FIELD CHANGE REQUEST FORM

NAVY CLEAN
ENSAFE/ALLEN & HOSHALL
(901) 383-9115

FIELD CHANGE REQUEST

E/A&H PROJECT NO. ________ FIELD CHANGE NO. ________

TO ________ LOCATION ________ DATE ________

DESCRIPTION:

REASON FOR CHANGE:

RECOMMENDED DISPOSITION:

FIELD MANAGER(SIGNATURE) ________ DATE ________

DISPOSITION:

SITE MANAGER ________ DATE ________

DISTRIBUTION:
- E/A&H PROJECT MANAGER
- QUALITY ASSURANCE MANAGER
- NAVY EIC
- FIELD MANAGER

OTHERS AS REQUIRED ________

CLNFCR

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Interim reports or technical memorandums will be completed as necessary to describe significant divergence of site conditions from those anticipated, secure concurrence on the need for emergency or interim corrective measures, or to gain regulatory input on unanticipated issues.

Tables, Graphs, and Illustrations: Data obtained from sampling and analysis procedures will be summarized and presented in tables. These tables will be supported by raw laboratory reports submitted to the EIC under separate cover. Several formats will be used to present sampling results graphically. Isoconcentration maps will be developed for soil and groundwater parameters, if possible. In addition, maps showing sample locations and results also will be completed. Groundwater surface contours, along with flow direction and gradient also will be displayed on the site base maps. Cross-sectional plots may be used if they would enhance understanding of the site. Forms completed during the investigation will be included in appendices of the report.

Accumulated data and analytical results will be interpreted as a project team effort. The expertise of each project team member will be used to develop proper conclusions and recommendations. The final decision about interpretation of data for the report will lie with the Task Order Manager, the Project Technical Director, and the South Carolina-registered Professional Geologist.

15.0 DECONTAMINATION

Decontamination procedures will be performed in accordance with Appendix B, Section B-8 of the ESDSOPQAM manual (included in volume V of the RFI Work Plan) for sampling equipment and in accordance with Appendix E, Section E-9 of the ESDSOPQAM manual for drilling equipment, with the following exceptions. The detergent for use on this project will be Liquinox™ because it contains powerful chelating agents to bind and remove trace metals from sampling equipment. When available, hot water will be used for field decontamination. A stainless-steel bowl, sink, or bucket will be used to contain the clean water wash solution. PVC well construction materials will not be solvent-rinsed or washed with hot water. Field reagent grade water will meet the specifications of ASTM Type III water (D 1193-77 re-approved 1983, federal test method 7916), providing deionized, filtered, and organic-free water for field use. The steam cleaner and/or high-pressure hot water washer will be capable of generating adequate pressure and producing hot water and/or steam. All wastes generated during decontamination will be containerized in designated drums for disposal by the Navy in accordance with Section 16 of this CSAP.

15.1 Decontamination Area Setup

Decontamination generally will occur at a designated area downgradient and downwind of the clean equipment storage area. The decontamination area is a concrete pad designed to promote surface runoff into a catch basin. Liquids contained within the catch basin will be pumped regularly into designated drums. All equipment will be cleaned on saw horses or auger racks above the concrete surface. If field cleaning is necessary, place plastic sheeting on the ground designated as the decontamination area to contain any spills.

15.2 Cross-Contamination Prevention

Follow procedures below to reduce cross-contamination risk during decontamination.

1. Don a new pair of disposable outer gloves before handling sampling equipment.

2. Use only Teflon™, glass, or stainless-steel spray bottles/pressurized containers to apply decontamination rinsates. Keep each solution in a separate container.
3. Transport all necessary decontaminated field equipment to each designated location to minimize the need for field cleaning.

15.3 Non-sampling Equipment

Non-sampling equipment includes drill rigs and backhoes. Any paint or coatings (e.g., rust) potentially touching a sample will be removed from the equipment by sandblasting before it is brought to the site.

1. Decontaminate with high-pressure steam.
2. Scrub with a laboratory-grade detergent and clean water wash solution.
3. Rinse with clean water as necessary.

15.4 Sampling Equipment

Sampling equipment includes any downhole equipment (e.g., augers, drill pipe, split-barrel samplers, Teflon™-coated stainless-steel leaders, stainless-steel liners, bailers, etc.) and any sampling utensils (e.g., stainless-steel spoons, stainless-steel spatulas, stainless-steel bowls, pumps, etc.) not dedicated to the sample location. Hollow downhole equipment or equipment with holes potentially transmitting water or drilling fluids will be cleaned on the inside and outside.

1. Don protective gloves before decontaminating the equipment.
2. Wash and scrub with a laboratory-grade detergent and clean water wash solution or decontaminate with high-pressure steam.
3. Rinse with clean water.
4. Rinse with organic free water.
5. Rinse twice with pesticide-grade isopropyl alcohol.
6. Rinse with ASTM Type III water.

7. Air dry. If weather prohibits air drying, repeat the isopropyl alcohol rinse and final ASTM Type III water rinse twice.
8. Wrap in aluminum foil or plastic sheeting for storage if the sampling equipment is to be stored or transported.
9. Augers and drill rods will be covered in clean plastic after decontamination.

Pump Decontamination

Pump decontamination differs from decontaminating most sampling equipment. The pump exterior and interior both require decontamination. The procedures for decontaminating the interior and exterior of the pump are outlined below:

1. Don protective gloves before decontaminating the equipment.
2. Immerse pump head in a detergent solution with the effluent hose prepared to discharge into a liquid IDW drum. A stainless-steel bucket or closed 4-inch pipe can be used to contain the pump head and pump solutions. All pump effluent will be containerized IDW.
3. Using a brush, scrub the exterior of the pump and hose with the detergent solution. Rinse the exterior of the hose with a clean water rinse solution followed by an ASTM Type III water rinse. Recoil the hose onto the spool.
4. Pump organic free water through the hose to purge the clean water rinse solution. Purge additional organic free water through the hose with the pump in reverse.
5. Rinse the outside of the pump housing and hose with deionized water.
6. Wrap the pump in plastic sheeting for transport to the field or for storage to prevent cross-contamination.

15.5 Personal Decontamination

Personal decontamination procedures are outlined in the comprehensive CHASP.

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16.0 INVESTIGATION-DERIVED WASTE

16.1 Introduction

The following discussion outlines the manner in which IDW will be managed to comply with all applicable requirements. IDW generated during the RFI will likely include soil produced while installing hand-auger borings, soil borings and monitoring wells; groundwater derived from completing and purging the monitoring wells; disposable PPE and sampling utensils; and decontamination fluids from cleaning of PPE, sampling equipment, and drilling equipment. As the IDW generator, the Navy will be responsible for the ultimate treatment, storage, or disposal of all IDW. E/A&H will provide technical assistance to the Navy while managing all IDW.

Federal environmental laws and regulations that are determine disposition of IDW at this site include RCRA (Land Disposal Restrictions [LDR]) and Corrective Action Program, the Toxic Substances Control Act (TSCA), and the Clean Water Act (CWA). State and local environmental laws and regulations also apply. The state regulations have a great impact on how IDW is managed, since South Carolina has promulgated more stringent requirements than the federal requirements for many programs, including the solid and hazardous waste program.

16.1.1 Resource Conservation and Recovery Act

RCRA was passed by Congress in 1976 to meet three goals: (1) to protect human health and the environment, (2) to reduce waste and conserve energy and natural resources, and (3) to reduce or eliminate the generation of hazardous waste as expeditiously as possible. The Hazardous and Solid Waste Amendments (HSWA) of 1984 significantly expanded RCRA by adding new corrective action requirements, LDR, and Minimum Technical Requirements (MTR).

RCRA is the most important federal statute for managing IDW, because it specifically regulates disposal of solid waste and all aspects of transportation, treatment, storage, and disposal of hazardous wastes. RCRA has 10 subtitles addressing specific waste management activities. Two of these subtitles and their implementing regulations are specifically applicable for IDW handling: Subtitle C (Hazardous Waste Management) and Subtitle D (Solid Waste Management). The regulations are codified in 40 CFR Parts 260 through 272.

RCRA was developed first and foremost as a prevention-oriented program, with its primary objective to prevent new releases resulting in contaminated sites. Following this objective, a stringent set of standards were developed to ensure human health and the environment were protected from such ongoing waste management. The Subtitle C regulations are specified as uniform, national standards that must be complied with at all RCRA-regulated facilities. These standards generally are considered very stringent because they must ensure an adequate level of protection nationally. The standards must prevent or minimize environmental releases over a wide range of hazardous waste types, environmental conditions, operational contingencies, and other factors. The HSWA amendments strengthened the RCRA prevention program by adding the LDR and MTR, which have become central features of the RCRA prevention program. These features added incentives to generators to minimize the amounts of waste being created by providing technology-based standards for treating hazardous waste, in the case of LDR, and designing land-based disposal units, in the case of MTRs.

Under RCRA Subtitle C, wastes are defined as hazardous based on their source or method of generation ("listed" wastes) or their chemical constituents or characteristics ("characteristic" wastes). The hazardous waste identification rules are codified in 40 CFR Part 261. For example, 1,1,1-trichloroethane is a listed waste when it is a spent solvent. Based on the "contained-in interpretation," soil, groundwater, and other investigation wastes containing this listed waste also would be considered hazardous (USEPA 1986). Characteristic hazardous wastes include those with one or more characteristics of ignitability, corrosivity, reactivity, and toxicity. Determining whether a waste is hazardous may be based on knowledge of the IDW and associated suspected or known contamination, rather than by direct testing (USEPA 1991). The IDW generator may choose to characterize the waste as hazardous or non-hazardous based on corporate knowledge of the history of the site and environmental data for the surrounding area, provided that knowledge or data are specific enough to enable waste characterization, without actually collecting a sample of the waste and testing it for hazardous waste parameters.

Land Disposal Restrictions: With respect to IDW management, the LDR program is one of the most significant provisions of RCRA. The LDR program, defined in RCRA Section 3004 and codified in 40 CFR Part 268, establishes technology-based standards that must be met before placing hazardous waste into land disposal units, which include landfills, surface impoundments, waste piles, and other land-based units. Hazardous waste generators must notify the receiving hazardous waste facilities that a waste is restricted from land disposal. Certification is required for all restricted wastes meeting LDR treatment standards when the waste is land-disposed.

For the purpose of managing IDW, land disposal occurs when any of the following activities take place:

- Wastes from different SWMUs or AOCs are consolidated and disposed of in one AOC.
- Wastes are moved outside of a SWMU/AOC for storage or treatment and are returned to the same or a different SWMU/AOC.
- Wastes are excavated from a SWMU/AOC, removed to a separate unit such as a tank, surface impoundment, or incinerator that is within the SWMU/AOC, and then are redeposited into the SWMU/AOC (USEPA 1991).

Waste that does not contain hazardous constituents as listed in 40 CFR Part 261 Appendix VIII or Part 264, Appendix IX and is not mixed with other contaminated IDW does not trigger LDR and may be replaced at the site from which it originated, provided the surface conditions permit (i.e., unimproved surfaces).

LDR limits the constituent concentrations of wastes that may be disposed in land units (such as landfills and surface impoundments). An important consideration in evaluating the applicability of LDR is whether land disposal of hazardous IDW will occur as a result of the proposed storage or disposal method. Based on the delineation of a SWMU/AOC, LDR do not apply when uncontained hazardous IDW (soil or sediment) is handled as follows:

- Capped in place
- Treated in-situ
- Processed within the SWMU/AOC to improve structural stability
- Left in place, moved, or stored within a single SWMU/AOC unit

LDR prohibits storing restricted hazardous waste beyond specified time limits, unless the purpose of storage is to accumulate sufficient quantities of waste to promote proper disposal, treatment, or recovery.

Corrective Action Program: In addition to the prevention-oriented provisions of RCRA, the HSWA corrective action program created a very different mandate for the RCRA program: cleaning up releases from SWMU at more than 4,000 RCRA TSDFs. While implementing these requirements and through its experience with the Superfund program, USEPA found that Subtitle C requirements, when applied to remediation wastes, could act as a disincentive to more protective remedies. These requirements also provided very limited flexibility in choosing the most practical remedy at a specific site. In response to this disincentive, USEPA developed two new types of waste management units, the Corrective Action Management Unit (CAMU) and the Temporary Unit (TU), as a mechanism for providing more regulatory flexibility at remediation sites while maintaining a standard of environmental protection.

CAMUs are land-based units that can be used to manage wastes during a site remediation. CAMUs provide two primary advantages:

- Placing remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes, so LDR standards are not triggered.

- Consolidating or placing remediation wastes into or within a CAMU does not constitute creating a unit subject to MTR.

TUs are for short-term operation of tanks and container storage units used for treating or storing remediation wastes. These units may only be used for remediation wastes, and they must be located at the facility where the remediation is occurring. TUs do not include incinerators, non-tank thermal treatment devices, or units regulated under 40 CFR Part 264 Subpart X (miscellaneous units). The corrective action regulations for temporary units provide that an alternative design, operating, or closure standard may be applied rather than the standards that normally apply to permitted facilities. Wastes can be stored in a TU for up to one year, with extensions available case-by-case.

16.1.2 Toxic Substances Control Act

Congress passed the TSCA in 1976 to establish requirements and authorities for identifying and controlling toxic chemical hazards to human health and the environment. While the majority of regulations promulgated under TSCA address chemical manufacturing, the law also covers the management and disposal of wastes containing PCBs in 40 CFR Part 761 and asbestos in 40 CFR Part 763. These regulations potentially affect IDW management in at least two ways:

- Non-hazardous IDW under RCRA that contains PCBs at concentrations greater than specified limits must be managed at facilities permitted under TSCA. Incineration is the most common option for wastes containing 50 parts per million (ppm) PCBs or greater.
- Non-hazardous IDW with PCB concentrations less than 50 ppm are generally not regulated under TSCA, although some states regulate these wastes as hazardous.

At this site, waste that contains any concentration of PCBs or asbestos will be regulated and disposed of as hazardous waste.

16.1.3 Clean Water Act

The CWA, developed in 1977, provides site-specific pollutant discharge limitations and performance standards for specific industries to protect surface water quality. During an investigation, the most likely situation where the CWA will be applied involves the indirect discharge of IDW water to a publicly owned treatment works (POTW) or a wastewater treatment plant for treatment. A less likely situation may involve direct discharge, either onsite or offsite, to surface water. The CWA also regulates criteria for selecting POTW and sets ambient water quality criteria (AWQC) to protect human health and aquatic life. Regulations under the CWA are codified in 40 CFR Parts 121 through 136.

16.2 Generation of IDW

Activities that may generate IDW during operations at IRP sites include site investigations, removal actions, and underground storage tank (UST) investigations. IDW may include drilling muds, soil cuttings, purged groundwater, decontamination fluids, disposable equipment (DE), and PPE.

16.3 Sources of IDW

Field activities performed during investigations that may generate IDW typically include some or all of the following:

ACTIVITY	WASTE
• Monitoring well installation	• Soil cuttings, decontamination fluids, drilling mud, PPE, DE
• Monitoring well development	• Development water, silt, decontamination fluid, PPE, DE
• Groundwater sampling	• Purge water, decontamination fluid, PPE, DE
• Soil boring	• Soil cuttings, drilling mud, decontamination fluid, PPE, DE

• Soil excavation/trenching	• Soil cuttings, decontamination fluid, PPE, DE
• Soil sampling	• Soil cuttings, decontamination fluid, PPE, DE
• Sediment sampling	• Sediment, decontamination fluid, PPE, DE
• Surface water sampling	• Decontamination fluid, PPE, DE
• Aquifer testing	• Development water, decontamination fluid, PPE, DE
• Radiation monitoring	• PPE, DE

The wastes described above will be sampled and analyzed for disposal and storage. Section 16.5 describes how this determination will be made and how IDW will be characterized. Once the IDW is characterized, a determination may be made as to the waste's proper management. In addition to the waste types listed above, general refuse may be generated during field activities, including packaging materials, broken or cut-off well screening and casings. This refuse will be managed as non-hazardous material and disposed of accordingly unless evidence exists that would indicate the possibility of contamination, in which case it will be managed as IDW.

16.4 IDW Volume Estimates

Various field activities conducted during the course of investigation activities may create IDW. Estimated typical volumes of IDW generated from field activities are shown below:

- **Screening:** Screening studies typically include soil-gas, soil-probe, geophysical surveys, and water-level measurements. These activities may generate several 55-gallon drums of decontamination fluid, PPE, DE, and groundwater during the course of the initial studies.

- **Drilling:** Drilling of an 8-inch-outside-diameter (OD) soil boring will generate a minimum of 0.35 cubic feet (ft^3), or 2.6 gallons of soil cuttings per linear foot of borehole. A 25-foot soil boring therefore would generate approximately 9.0 ft^3, or 65 gallons, of soil cuttings (approximately 1.25 55-gallon drums). Table 16-1 shows the relationship between the diameter of the borehole and the potential volume of soil cuttings generated. Larger-diameter soil borings will generate proportionately larger quantities of soil. Additional soil quantities should be expected due to soil expansion following removal from the borehole (known as the "fluff" factor) and slough created during drilling, especially if poorly consolidated materials are encountered. It is estimated that the fluff factor increases soil-cutting volumes 30 percent. Soil cuttings generated during drilling will typically be placed into 55-gallon containers.

- **Well Development or Purging and Groundwater Sampling**: The volume of groundwater generated through monitoring well development and groundwater sampling depends on a number of variables, including the turbidity of the groundwater, well diameter, length of screened interval, diameter of the saturated filter pack, and porosity of the material used as filter packing.

  Complete well development requires removing at least three times the amount of water used during drilling and constructing the well, plus three times the volume of the standing groundwater in the well. Table 16-2 shows the estimated water volumes for various well screen diameters and borehole radius, and assumes a 30 percent porosity within the filter pack.

Table 16-1
Volume of Soil Cuttings Generated for Typical Diameter Boreholes

Hole Diameter (inches)	Undisturbed Volume of Soils per Lineal Foot of Hole		Volume of Loose Soil per Lineal Foot of Hole	
	Gallons	Cu. Ft.	Gallons	Cu. Ft.
6.0	1.5	0.20	2.0	0.26
8.0	2.6	0.35	3.4	0.46
10.0	4.0	0.54	5.2	0.70
12.0,	5.8	0.78	7.5	1.01

Notes:
Miscellaneous Data:
1 Cu. Ft. = 7.5 gallons (approximately)
1 Gallon = 0.134 Cu. Ft. (approximately)

Table 16-2
Volume of Water Generated for a Typical Well Casing and Borehole Combination

Well Casing/Boring Diameter (inches)	Volume of Water Generated per Lineal Foot of Hole (gallons)
2/8	0.9
4/10	1.2
4/12	2.2

For example, a 4-inch well with a 10-inch borehole would contain approximately 1.2 gallons of fluid per foot of saturated zone. If no additional construction water was used and only three volumes of water were pumped to develop 15 feet of saturated material, the well would produce approximately 54 gallons of fluid.

For hollow-stem drilling, additional water typically is used for flowing sand conditions and when soil conditions bind the augers. For normal well construction, minimal additional water would be used. Additional water would be generated during later purging and sampling and would be specific to the conditions for the well.

The water generated during these activities will typically be placed in 55-gallon containers or in portable storage tanks.

- **Aquifer testing**: Aquifer tests that may be conducted at the NAVBASE may generate large quantities of groundwater, depending on the hydraulic properties of individual screened formations. A well installed in a formation with high transmissivity will sustain a higher pumping rate and generate greater quantities of water. A typical test may run for 24 to 48 hours and generate up to several gallons per minute (gpm). With large volumes such as these, it will be necessary to use 20,000-gallon portable tanks to store water generated from these tests. This water will typically undergo onsite pretreatment for disposal to a POTW. Slug tests typically will generate a small to moderate volume of decontamination fluid. In some instances, it may be possible to combine fluids from several different aquifer tests into one storage container.

- **Trenching and Subsurface Exploration**: For trenching or other large-volume excavations, it will be necessary to store the wastes in large covered roll-off bins or on an appropriate liner material and provide a cover. If possible, and when appropriate and approved by the regulatory agencies, the best option may be to return the materials to the excavation. Due to the large volumes of materials associated with this type of exploration, it is best to consider other suitable investigative techniques.

- **PPE, DE, and Decontamination Fluid**: The volume of IDW generated as PPE, DE, and decontamination fluids during each field activity depends on a number of site-specific factors and will therefore vary in quantity. Site-specific factors include the USEPA health and safety work level (Level D, Level C, or Level B), number and type of field activities per site, and total number of sites being investigated. PPE waste volumes will typically account for one-half of a 55-gallon container per day for a crew of four. Decontamination fluid will vary from a few gallons per day for decontaminating monitoring instruments to several hundred gallons per day for large equipment such as drilling rigs.

16.5 IDW Characterization

The process of identifying and characterizing IDW will be started when planning field activities. Characterizing IDW is a multi-step process that involves determining the origin of the waste and then considering the chemical contaminants and their concentration in the waste. Typically, sampling data obtained from site characterization or investigation activities will provide an initial determination of whether a waste is hazardous or non-hazardous. IDW will be sampled and analyzed to provide additional information and to determine specific hazardous waste characteristics. Environmental samples relevant to IDW are soil samples (for soil cuttings and excavated soil) and groundwater samples (for purge water and development water).

The RCRA program recognizes two general classes of solid waste at the federal level: hazardous and non-hazardous. Hazardous wastes are defined by either being a listed waste, by origin, or by contaminant concentrations in the waste. A characteristic waste exhibits properties of ignitability, corrosivity, reactivity, or toxicity. A hazardous waste may be characterized as both a listed and a characteristic waste.

16.5.1 Listed Hazardous Waste

E/A&H project manager is responsible for identifying any potential listed hazardous wastes that may be present at the site to the NAVBASE Occupational Safety, Health and Environmental Office (Code 106). The project manager establishes the site's history and use, and determines whether activities there generate, or have generated, listed hazardous wastes. Examples of activities that may generate listed wastes include using solvents, rinsing and managing pesticide containers, electroplating, dry cleaning, landfills, chemical disposal areas, surface impoundments and equipment storage areas. Every available source of site information, manifests, storage records, and vouchers will be researched to ascertain the source of these contaminants. The environmental analytical data should be reviewed to determine if the IDW contains any hazardous constituent found in the RCRA listed waste. USEPA's "contained-in" policy states that media such as soil and groundwater that contain a listed hazardous waste must be managed as a listed hazardous waste until they no longer contain that waste. No established policy exists on how to determine when the media no longer contain the listed hazardous waste. Usually this is determined on a case-by-case basis. Two aspects should be considered for managing IDW: whether the waste may also be hazardous for characteristics (as described in Section 16.5.2) and whether the cost of additional analytical work will offset the cost of managing the waste as a listed hazardous waste.

16.5.2 Characteristic Hazardous Waste

Characteristic hazardous wastes are based on general criteria. In order for a waste to be considered a characteristic hazardous waste, it must exhibit one or more of the following properties, as defined in 40 CFR Part 261.21 through Part 262.24:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity
  - Heavy Metals
  - VOAs
  - SVOAs
  - Pesticides and herbicides

IDW does not usually exhibit the characteristics of ignitability, corrosivity, or reactivity due to the nature and matrix of the waste. Typically, IDW wastes consist of low concentrations of contaminants in soil and water. The quantities of these contaminants are typically not sufficient to cause the soil or water to exhibit any of the characteristics of ignitability, corrosivity, or reactivity.

The characteristic for toxicity is based on the leaching characteristics of the waste. The TCLP simulates the effect of hazardous constituents leaching from a waste, and regulatory limits to protect human health and the environment are set by USEPA based on the TCLP test. Environmental data are reviewed to initially screen the IDW to help eliminate some or all of the toxicity characteristics. USEPA provides that if a total analysis demonstrates that individual constituents are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory levels could not possibly be exceeded, the TCLP need not be run (40 CFR Part 261 Appendix II).

16.5.3 Sampling and Analysis

IDW would be sampled and analyzed when corresponding environmental sample data are not available or when additional information is needed about the waste. All samples collected for waste analysis should be representative of the waste being sampled. Guidelines for collecting representative samples are contained in Chapter 9 of SW-846, *Test Methods for Evaluating Solid Waste* (USEPA 1986a).

16.5.4 Waste Profile

IDW is characterized through knowledge of the waste, review of environmental data that correlate to the waste, or sampling and analyzing the waste itself. This characterization leads to a waste profile summarizing all the information available on the IDW. The waste profile is required for shipping any IDW to offsite facilities. It will be completed by NAVBASE Occupational Safety, Health, and Environmental Office (Code 106) for all wastes generated in investigation activities as an accurate record of the waste identification, source, and characteristics. The waste profile is used to describe wastes that are generated consistently and that have similar or identical characteristics. The waste analysis and profile procedures will be in accordance with NAVBASE Environmental Protection Manual, Volume II-10, Standard Operating Procedure No. 8, which is available for review in the Code 106 office.

16.5.5 Management of Disposable PPE and Equipment

Disposable PPE and DE will be managed according to the type of activity and level of contamination encountered with the equipment. Non-hazardous IDW will be appropriately labeled and placed in plastic bags to be transferred to an onsite industrial dumpster, whose contents are disposed of in an municipal landfill.

PPE and DE will be placed in 55-gallon drums, accurately labeled as discussed in Section 16.7 and stored at a container storage area. They will be stored until adequate characterization is complete for the site or containerized PPE and DE. The environmental sampling results from the sites where the IDW was generated will be reviewed upon receipt. PPE and DE contaminated with hazardous waste will be managed as hazardous waste, and will be characterized in a manner consistent with the media being sampled.

16.5.6 Management of Empty Drums

Empty drums may be generated in rare cases, such as when IDW is consolidated onsite to minimize the number of containers shipped to offsite waste management facilities. Empty drums also may be generated when IDW is removed from containers for treatment or disposal onsite. Federal regulations require that empty containers that held hazardous waste to be emptied to the maximum extent practical. In addition, if the container was used for an acutely hazardous waste, it must be decontaminated via triple wash and rinsing before any further use.

16.6 Storage

Specific storage requirements for IDW depend on a number of factors, including the location of the storage area, the length of storage, the type of storage unit, the type of waste, and the regulatory status of the storage unit. Storing non-hazardous waste and designated waste in drums and portable tanks is not regulated by USEPA.

Storage of hazardous waste is regulated on the federal and state levels with three available options:

- Storage in a TU
- Storage for up to 90 days from the date of characterization
- Storage in a unit that meets permitted facility standards

These storage units may be located within the SWMU/AOC, within a designated CAMU, at a designated storage area on the installation, or at the permitted storage facility.

16.6.1 Storage in a TU

Storing waste in a TU provides the greatest flexibility for the design and operation of the storage unit. A temporary storage unit may be established for containers or tanks and may be located either within or outside an SWMU/AOC or CAMU. A major advantage of the TU is that IDW may be stored for up to one year, and waste may be removed from the TU and returned to the SWMU/AOC or CAMU for treatment or disposal without triggering LDRs or MTRs. TUs must be administratively created with regulatory agency input. Design of a TU must consider:

- Length of time the unit will be in operation
- Type of unit
- Volumes of wastes to be managed
- Physical and chemical characteristics of the wastes to be managed in the unit
- Potential for releases from the unit
- Hydrogeological and other relevant environmental conditions at the facility that may influence the migration of any potential releases
- Potential for exposure of humans and environmental receptors if releases were to occur from the unit

Specific design and operating requirements for accumulation storage areas and permitted storage units may be used as guidelines in developing temporary storage units. It is important for the Navy and E/A&H to determine whether the TU will reside within a SWMU/AOC or CAMU, and the specific SWMU/AOC or CAMU should be identified in site-specific plans for the TU.

16.6.2 Less-than-90-Day Storage Areas

Generators may accumulate hazardous waste in container storage areas or storage tanks for up to 90 days before shipment to an offsite TSDF. These storage areas and tanks are commonly called Less-than-90-day storage facilities. An area adjacent to Building 1278 has been designated as less-than-90-day storage for IDW.

Accumulation container storage areas must meet specific design and operational requirements outlined in 40 CFR §262.34(a) and R.61-79.262 Subpart C, which include the following:

- Containers must be in good condition and compatible with the waste place inside them.
- Containers must be kept closed, except when waste is being added or removed, and they must be managed in a manner preventing rupture or leakage.
- Containers must be marked as hazardous waste and with the accumulation start date, composition and physical state of the waste, hazardous properties of the waste, and the name and address of the generator.
- The accumulation storage unit must be inspected and recorded at least weekly.
- Personnel handling the containers must receive initial and annual training related to operating and maintaining the accumulation storage unit. Code 106 personnel will provide IDW handling and have received HAZWOPER training for TSDF personnel as required by 29 CFR 1910.120.
- A contingency plan must be developed and emergency equipment provided for the accumulation storage unit. The contingency plan outlined in the Part B permit application for the NAVBASE satisfies this requirement.

- The accumulation storage unit must be closed to meet the RCRA closure performance standard. The less-than-90-day storage area at Building 1278 will be closed under the requirements of 40 CFR Part 264.111 and 264.114.

16.6.3 Permitted Container Storage Facility

The last storage option for IDW is to store it in a facility that meets all the design specifications and operating requirements applicable to permitted facilities. The requirements for permitted facilities were developed to allow longer storage of a variety of wastes generated at industrial facilities, and these requirements are the most stringent under RCRA. Buildings 246 and 1640 meet these requirements for storage of wastes listed in the Part B permit. The list however does not contain many of the P- and U-listed wastes found during preliminary investigations, which necessitates the less-than-90-day storage area at Building 1278. Storage at a less-than-90-day area does not require the permit to list the constituents being stored.

16.6.4 Inspections and Inventory Log

The storage areas (TU and 90-day accumulation) will be inspected at least weekly. A standard inspection form is kept by Code 106 for the Building 1278 storage area, showing the items to be inspected, discrepancies noted, and corrective actions taken. Container storage inspections cover the following areas:

- Condition of containers
- Adequacy and completeness of labels
- Evidence of leaks and spills
- Adequate aisle space
- Loading and unloading areas
- Emergency equipment

In addition to completing weekly inspections, an inventory of containers will be maintained by Code 106 that reflects the following information:

- Number of containers currently in storage
- Date each container was characterized
- Dates, manifest numbers, and destination facilities for IDW that is shipped to offsite management facilities
- Dates and disposition information for IDW that is disposed of onsite

16.6.5 Use of Portable Storage Tanks

Portable storage tanks often are used to accumulate and store liquid IDW, such as groundwater or storm water runoff. USEPA regulates these portable tanks as containers for storage onsite. Storage tanks should be labeled in the same manner as containers. However, if the portable tanks will be used to transport liquids to facilities outside the installation, U.S. Department of Transportation (DOT) regulations for container specifications and labeling must be complied with.

16.6.6 Repackaging and Overpacking Containers

Containers may require repackaging or overpacking if they become damaged or weathered and are no longer suitable for use. Repackaging involves transferring the waste from the damaged drum into a new container, whereas overpacking involves placing the damaged drum into a larger container. When repackaging or overpacking occurs, the new container must be labeled in an identical manner, and a note should be made in the field logbook or storage inventory log of the change in packaging or drum size.

16.7 Container Labeling

Waste labeling and record-keeping requirements include initial labeling of containers: "ANALYTICAL RESULTS ARE PENDING ON THE CONTENTS IN THIS CONTAINER." A completed label should include the following information: date contents were placed in container, sample identification number(s) (See Section 11), IDW type, source site number, and boring or monitoring well number. A sample drum label used for identifying containerized IDW pending characterization is shown in Figure 16-1.

All labeling information for each drum will be entered into the field logbook. After the drums' contents are characterized, as described in Section 16.5, the labels will be replaced to reflect the appropriate classification of wastes within the drums and the logbook will be updated.

Drums containing hazardous IDW will be labeled "HAZARDOUS WASTE — South Carolina Law Prohibits Improper Storage or Disposal. If found, contact nearest police or public safety authority or the S.C. Department of Health and Environmental Control" in accordance with 40 CFR Part 172 and the applicable South Carolina Public Service Commission regulations (Figure 16-2). Drums containing non-hazardous IDW will be labeled "NON HAZARDOUS WASTE" (Figure 16-3). Drum labels will be placed on the side of the drum, not on the lid, to reduce weathering and to prevent the possibility of interchanging labels if lids are reused.

Plastic bags containing PPE and DE will be identified with a drum label wrapped around a piece of wire to produce a tag that will close the bag. In addition to labels, drums will be painted with unique identifiers in case the labels are lost or removed. The identifier will include the site number and a unique identification number and will be entered into the field logbook or storage inventory log.

16.8 Treatment and/or Disposal of IDW

Once the waste characterization process has been completed for IDW, treatment and disposal options may be considered that provide for appropriate waste management. The options available at a particular installation depend on:

- Availability of onsite management facilities, such as wastewater treatment plants, bioremediation facilities, and other treatment technologies that may have been developed for other cleanup sites.

- Availability of municipal POTW with the capability to treat wastewaters generated at the installation.

- Site conditions and regulatory approval for disposal of non-hazardous soil back onto the site where generated. Soil that does not contain chemicals of potential concern (COPC as defined by the Baseline Risk Assessment) above background concentrations will be recommended to be placed back on the site where generated.

- Any soil or sediment that contains COPCs at concentrations that may pose a risk to human health and the environment but is not determined to be a hazardous waste will be handled as a hazardous material. Proper disposal will be coordinated with the Navy, USEPA, and SCDHEC.

The offsite waste management options addressed in this section include management of aqueous liquids at installation wastewater treatment plants, management of aqueous liquids at POTWs, and management of offsite facilities using the waste management subcontract.

NAVY CLEAN
ENSAFE/ALLEN & HOSHALL
(901) 383-9115

ANALYTICAL RESULTS ARE PENDING ON THE CONTENTS OF THIS CONTAINER

THE CONTENTS WERE GENERATED FROM AN ENVIRONMENTAL INVESTIGATION

THIS CONTAINER HAS: ☐ SOIL
☐ GROUND WATER
☐ THIS CONTAINER HAS:
☐ THIS CONTAINER HAS:

SOURCE: SITE ______
MW/SB# ______
DEPTH ______
DATE: OPENED ______
SEALED ______

DRUM # ______

CONTACT ______ FOR FURTHER INFORMATION

THIS CONTAINER WILL BE APPROPRIATELY LABELED AND THE CONTENTS DISPOSED OF ACCORDING TO FEDERAL AND LOCAL REQUIREMNETS WHEN THE LABORATORY RESULTS ARE KNOWN

HANDLE WITH CARE

FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 16-1
DRUM LABEL
DATA PENDING

DATE: 08/08/94 | DWG NAME: 29DRMLBL

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HAZARDOUS WASTE

FEDERAL LAW PROHIBITS IMPROPER DISPOSAL

IF FOUND, CONTACT THE NEAREST POLICE, OR
PUBLIC SAFETY AUTHORITY, OR THE
U.S. ENVIRONMENTAL PROTECTION AGENCY

PROPER D.O.T.
SHIPPING NAME ______________________ UN OR NA# ________

GENERATOR INFORMATION:

NAME ____

ADDRESS ____

CITY __________________________ STATE ________ ZIP ________

EPA
ID NO. ____________________

EPA
WASTE NO. ____________________

ACCUMULATION
START DATE ____________________

MANIFEST
DOCUMENT NO. ____________________

HANDLE WITH CARE!

CONTAINS HAZARDOUS OR TOXIC WASTES

STYLE WM 6

Printed by LABELMASTER, Div. of AMERICAN LABELMARK CO. CHICAGO, IL 60646

FINAL CSAP
NAVAL BASE
CHARLESTON
CHARLESTON, S.C.

FIGURE 16-2
HAZARDOUS WASTE LABEL

DWG DATE: 08/08/94 | DWG NAME: 029HWLBL

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NAVY CLEAN
ENSAFE/ALLEN & HOSHALL
(901) 383-9115

INVESTIGATIVE DERIVED WASTE

NON-HAZARDOUS

ACCUMULATION
START DATE ______________________

CONTENTS
(CIRCLE)

SOIL WATER PPE

HANDLE WITH CARE!!!

FINAL RFI CSAP
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 16-3
DRUM LABEL

DATE: 08/08/94

DWG NAME: 029IDHW

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16.8.1 Disposal of Aqueous Liquids through POTW

NAVBASE currently is operating under a National Pollution Discharge Elimination System (NPDES) permit issued by the North Charleston Sewer District. Discharging IDW to the POTW will be considered under certain circumstances. Pursuant to the conditions of the NPDES permit issued to the facility from the state, any discharge of aqueous IDW will not exceed concentrations specified for listed constituents. Discharge of aqueous IDW will not occur until the POTW (North Charleston Sewer District) has reviewed the analytical data of the drum contents and onsite pH is taken by a state-certified laboratory technician.

16.8.2 Disposal of IDW through Offsite TSD Facilities

Currently Code 106 manages IDW within the hazardous waste management program at NAVBASE. The disposal is accomplished by another command, Defense Reutilization and Marketing Office (DRMO), under contract with an offsite TSDF. The Navy EIC and E/A&H may chose to establish a subcontract or use existing waste disposal subcontracts with waste management firms to provide waste management services for IDW including pickup, transportation, treatment, storage, and disposal of waste.

IDW transportation is coordinated and scheduled by Code 106. Code 106 is responsible for ensuring the following documentation is generated as well as maintenance of records for time specified in state regulations:

- **Uniform Hazardous Waste Manifest.** This document is used for cradle-to-grave tracking of waste regulated as RCRA hazardous under the federal regulations, and waste regulated as non-RCRA hazardous under South Carolina regulations. It must be signed by the generator (specifically, the Navy installation point of contact) before the shipment leaves the installation. The first transporter also must sign the manifest before the shipment leaves the installation, and the generator copy of the manifest is retained by the Navy installation point of contact.

- **Non-hazardous Waste Manifest.** This document is used to track all IDW shipments of non-hazardous waste, including waste that is shipped to Class II and Class III landfills in South Carolina. The non-hazardous waste manifest also may be used for non-hazardous waste shipped to facilities outside South Carolina. The non-hazardous waste manifest is signed by the generator and the first transporter before the shipment leaves the installation, and the generator retains a copy.

- **Land Disposal Restriction Notification.** This notification is required for all RCRA hazardous waste that is restricted from land disposal under 40 CFR Part 268 and for RCRA hazardous and non-RCRA hazardous waste that is restricted from land disposal under R.61-79.268. This notification is signed by the waste generator, and it tells the receiving facility what standards must be met for the waste before it can be placed in a hazardous waste landfill. A copy of the LDR notification is kept by the generator, and the original is attached to the manifest. A shipment of waste may have more than one LDR notification that contains standards for several different waste streams.

- **Land Disposal Restriction Certification.** An LDR certification is required when a restricted waste is shipped directly to a hazardous waste landfill without pretreatment because it already meets the applicable treatment standards. The generator must certify that all the applicable standards have been met, and waste analysis to support that must be attached to the certification. A copy of the LDR certification is kept by the generator, and the original is attached to the manifest.

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APPENDIX A

COMPREHENSIVE SAMPLING AND ANALYSIS PLAN REVIEW FORM

Orientation Meeting

Instructions for Use: Before performing any actions at Naval Base Charleston, E/A&H personnel will attend an orientation meeting at which the following requirements will be fully explained. Sign and date this form to indicate that you have reviewed these requirements.

General Requirements

- ☐ Charleston map showing locations of Naval Base Charleston and selected courier office
- ☐ Map of Naval Base Charleston showing locations of site and site office trailer
- ☐ Health & Safety Plan (See Health & Safety Officer)

Sampling Requirements

- ☐ Unified Soil Classification System (USCS)
- ☐ Stainless Steel Sleeves
- ☐ Sample Numbering System
- ☐ QA/QC Frequency
- ☐ QA/QC Definitions
- ☐ Sample Packaging

Documentation Requirements

- ☐ Field Forms
- ☐ Field Logbooks
- ☐ Photographs

Acceptance

I have reviewed and understand all of the requirements listed above for field activities at Naval Base Charleston.

____
Name

____
Date

APPENDIX B

OPERATING MANUAL FOR HYDROLAB DATASONDE 3 DATALOGGER

Hydrolab Operating Procedures

The Hydrolab Datasonde 3 (DS3) Multiparameter Water Quality Datalogger is an on-line transmitter of in-situ water quality measurements. The device measures temperature, pH, dissolved oxygen (DO), conductivity, salinity, depth, and Redox readings in lakes, streams, estuaries, or other large or small water bodies. The DS3 is designed for multi-mode operation. Data output can be continuously monitored, or the unit can operate remotely with data stored on board until downloading. Its digital output can be displayed, logged, and downloaded to a personal computer, or remotely transmitted through a modem or communications link. The device is built for operation in abusive field conditions.

DS3 Data Display Variables (Accuracy)

- Temperature in deg C/F (±0.15°C)
- pH in units (±0.2 units)
- Redox in millivolts (±20mV)
- Dissolved Oxygen (DO) in milligrams per liter (mg/l) or % Saturation DO (±0.2mg/l)
- Conductivity in milliSiemens/cm, microSiemens/cm, K ohms/cm, or resistivity (±1% of range)
- Salinity in ppt or total dissolved solids (TDS) (±0.2ppt)
- Depth (feet or meters) in level or total level (±0.45m)

The DS3's waterproof cylindrical core is constructed of durable plastic and contains a battery pack, a real-time clock, a solid-state memory package, and logging software. Attached to the lower end of the core is a multi-probe unit containing a temperature sensor, a specific conductance/salinity sensor, a pH glass electrode, a Redox sensor, a DO sensor, and a depth sensor. The lower end also contains the unit's sensor guard and ballast weight, or stirrer assembly. The upper end of the DS3 unit contains the an RS-232 data output port, and a stainless steel anchoring bail.

Standard Operating Mode
Once communication is established between the DS3 and computer, the following introductory
heading will appear on-screen:

HYDROLAB Datasonde 3 VX.YZ
(C)opyright 1990 Hydrolab Corporation

Time	Temp	pH	SpCond	Salin	DO	DO	Redox	Depth	Batt
HHMSS	deg C	units	ms/cm	ppt	%Sat	mg/l	mv	meters	volts

This header appears only if the header function of the Variables Menu is enabled. The header denotes the DS3's software version, its alpha-numeric name, measurement parameters currently enabled, and the current measurement variables selected for those parameters. If these features are changed after the program is entered, the new alpha-numeric name and parameters will be displayed when communication with the unit is re-initiated. Immediately following the appearance of the header, the DS3 will enter its Standard Operating Mode (SOM), whereby row after row of parameters will appear on screen. the third and fourth lines of the introductory header will be reprinted once every 24 lines so the columns can be identified once the initial header has scrolled off-screen.

The Basic Menu

The Basic Menu is accessed from the SOM by hitting the space bar. The following then appears on-screen:

HYDROLAB Datasonde 3 V X.YZ

— (P)arameters
— (C)alibrate
— (V)ariables
— (L)ogging
— (H)eader
— (M)easure
— (I)dentity
— or (Escape or Ctrl X to cancel)

Typing any of the letters in parentheses will allow access to the menu of interest. Each entry within a menu results in the program returning to the SOM. The menu selection must therefore be re-accessed via the Basic Menu after each entry is made.

- **Parameters**

Typing a "P" will access the Parameters Menu, providing the following display:

— (p)H
— Specific (C)onductivity/Resistivity
— (S)alinity/TDS
— (%)Sat
— D(O)
— (R)edox
— (D)epth/Level
— (B)attery
— (A)ll
— or (Escape or Ctrl X to cancel)

Selecting the letter in parentheses allows individual parameters to be enabled or disabled from this menu. Care should be taken when using this function, as certain parameters are depend upon others. For instance, disabling all forms of specific conductance will automatically disable DO, or enabling DO will automatically enable specific conductance. Time and Temperature cannot be disabled.

- **Variables**

Typing a "V" from the Basic Menu will access the Variable Menu, which allows default settings to be made for measurement variables. The Variable menu appears as follows:

— (T)emperature
— Specific (C)onductance/Resistivity
— (%) Sat
— D(O)
— (D)epth/Level
— (A)utolog
— SDI-12 Addr(e)ss
— SDI-12 De(l)ay
— (H)eader
— (B)uzzer
— (S)tirrer
— E(x)pert
— Ba(u)d Rate
— or (Escape or Ctrl X to cancel)

Typing any letter in parentheses will allow selection of a particular feature from the Variable Menu.

Temperature

This feature allows the temperature variable to be manipulated. Either the Centigrade or Fahrenheit scales are selected for temperature measurement.

Specific Conductance/Resistivity

This feature allows either specific conductance or resistivity to be selected as a measurement value, and permits additional attributes to be adjusted. Succeeding choice of measurement value, the presentation of this value is selected in either milliSiemens/cm or microSiemens/cm. Following selection of presentation format, the type of cell block is selected (freshwater if specific conductances between 0-10 mS/cm are anticipated, seawater if specific conductances greater than 10 mS/cm are anticipated). The specific conductance measuring range is then chosen. The measuring range can be automatic, or readings can be made in the high, medium, or low range. The next item selected is for salinity to be measured, or TDS. The final item selected is for specific conductance/resistivity and salinity/TDS readings to be compensated or uncompensated for temperature.

% Sat

This feature allows a barometric pressure that is different from the calibration value to be entered, if necessary.

DO

This feature allows certain aspects of the DO measurements to be specified. Standard or Hydrolab LoFlow membranes are selected, as are whether readings are to be compensated for salinity, or uncompensated.

Depth/Level

This feature allows manipulation of the depth/level variable. Either meters or feet are chosen to express depth. Following selection of the variable, either "depth" or "level" is chosen, depending on how the DS3 is equipped. If the unit is equipped with a depth transducer (having a range of 0 to 100 meters), depth is chosen for this expression. If the unit has a level transducer (having a range of 0 to 10 meters), level is chosen for this expression. The transducer type is printed on the DS3's label.

Autolog

This feature allows access to Autolog. This function enables or disables the automatically started logging sequence, which provides a record of all parameters once each hour. An enabled autolog can provide backup data for situations where the starting time or date, stopping time or date, or interval time has been incorrectly specified. Also, if for some reason there is a reset of transmitter electronics (power fluctuations, etc.), Autolog is set by default to be enabled.

SDI-12 Address

This feature allows the unit to be personalized. The SDI-12 address that the user wishes to assign a particular DS3 is entered.

SDI-12 is an interface bus designed to allow connection of a wide variety of transducers without having to worry about incompatible sensor outputs. It sends information to a single data recorder (the SDI-12 Controller) with a single cable bus.

SDI-12 Delay

This feature allows incorporation of a measurement delay (normally 30 or 120 seconds).

Header

This feature allows the display of header information to be enabled or disabled. If enabled, header information is included in the data lines.

Buzzer

This feature allows the buzzer function to be enabled or disabled. If enabled, a buzzer sounds each time a reading is made.

Stirrer

This feature allows the stirrer function to be enabled or disabled. Once enabled, the DS3 automatically actuates the stirrer for each logging run.

Expert

This feature enables or disables the expert function, which abbreviates items appearing on the menu screen and data printout.

Baud Rate

This feature allows the unit to be set to a different baud rate before dumping a memory file. The DS3 starts up ap 1200 baud. However, 1200 baud is not fast enough to keep up with a DS3 during recovery of logged data. The Baud Rate feature allows selection from five available baud rates (9600, 44800, 2400, 1200, or 300). The communications program for the computer will need to be set to the selected baud rate.

Report

This feature provides a report of all of the default settings currently selected from the Variable Menu.

- **Calibration**

Before deploying the DS3, the unit should be checked for calibration and operation. Calibration should also be checked periodically when the unit is deployed in the field for extended periods. The unit is calibrated by pouring a calibration standard into the calibration cup that comes with the apparatus. Alternately, the entire unit can be immersed in a bucket of calibration standard.

Typing a "C" from the Basic Menu will access the Calibrate Menu, which is displayed as follows:

— (p)H
— Specific (C)onductivity/Resistivity
— (S)alinity/TDS
— (%)Sat
— D(O)
— (R)edox
— (D)epth/Level
— (L)abel
— (T)ime
— (I)nterval
— (M)essage
— or (Escape or Ctrl X to cancel)

Typing any of the letters in parentheses will allow calibration of that particular function. Temperature is permanently set at the factory and cannot be field calibrated.

pH

pH calibration is initiated by using a pH 7 buffer solution to first adjust the pH system's zero. Subsequently, a slope buffer solution is used to adjust the pH system's slope. The unit will accept any pH value between 6.8 and 7.2 for the zero setting. Typing in the value of the buffer automatically calibrates the pH system to zero. To adjust pH slope, the calibration procedure is repeated with the slope buffer solution. The slope buffer value must be below 6.8 or higher than 7.2 for proper adjustment.

Specific Conductance/Resistivity

Specific conductance calibration is initiated by monitoring readings until they have stabilized for the standard solution, and then entering the value for the standard. If the default setting has been set to measure resistivity, the resistivity value for the standard is entered.

Salinity/TDS

Salinity calibration is initiated by accessing the salinity/TDS function. If the default setting is set for salinity, the value of the salinity calibration standard in parts per thousand at 25°C is entered. If TDS is the default selection, the TDS for the calibration standard is entered.

Dissolved Oxygen

DO calibration can be set for % saturation or for mg/l. Type "%" to calibrate for % saturation. Once into this function, enter the local barometric pressure (in millimeters of mercury). This adjusts calibration for <u>both</u> DO mg/l and DO % saturation (calibration should be 100.0 for the standard membrane, or 102.5 for the Hydrolab LoFlow membrane). Alternatively, type "O" to calibrate for DO mg/l. Enter the local barometric pressure as before, subsequently entering the DO concentration of the calibration standard as measured via Winkler titration or other instrumentation.

Redox

The Redox value of the calibration standard can be entered upon access to the Redox function.

Depth/Level

Depth calibration can be zeroed in air, at or near the surface of the water to be sampled, or at a known water depth. The depth is entered in either meters or feet, depending upon the default variable.

Additional Features of the Calibrate Menu

Entering the Label function allows the name of the transmitter to be changed (up to 12 characters). Accessing the Time function, allows the month/day/year/time to be entered. The military time format is used (HHMMSS). The Interval function allows the time to be set for the data printing interval. The Message Interval allows notes to be entered into the data record being created, if necessary, to help maintain clarity of the record.

- **Logging**

The Logging Menu allows the set up of a logging routine for automatic, unattended monitoring. The DS3 transmitter can log in two forms of memory, depending upon the configuration of the unit. Standard memory can log up to 32,000 readings (allowing all parameters to be logged twice an hour for approximately 60 days). Extended memory can log up to 70,000 readings.
If information is downloaded to a computer, the PC must be IBM compatible, possess a serial or COMM port, have DOS version 2.0 or higher installed, and be compatible with a DB25F to DB25M adapter cable. The PROCOMM Plus Software Terminal Emulator Program is required to properly interface the PC with the DS3. To communicate with a PC, make sure the baud rates for both DS3 and computer are compatible. The unit's default setting is 1200 baud, but can be changed through the Variable Menu. An interface cable, underwater cable, or calibration cable can be used to connect the DS3 to the computer. Since the DS3 needs to be powered during the logging sequence, sufficient battery power needs to be available. Once connected, if the DS3 and computer are properly interfaced, pressing the space bar accesses the SOM/Basic Menu.

Typing an "L" from the Basic Menu allows access to the Logging Menu, which is displayed as follows:

— (D)ump
— (E)rase
— (S)etup
— S(t)atus
— (R)eview
— (A)nnotate
— St(o)re
— or (Escape or Ctrl X to cancel)

Typing any of the letters in parentheses will allow entry into that particular logging function.

Dump

This feature allows the user to erase files no longer needed. Logging runs can be set up, and data files can be reviewed. Data storage on the manual file can be initiated, or this file can be annotated. Data can be dumped as "printer ready" if it is to be used for disk archiving or for word processing. Data can also be dumped into a file that is pre-formatted for a spreadsheet.
The Dump function allows selection of different configurations of variables/calibrations:

— Variables/calibrations in effect when the logging run was setup can be used,

— If re-calibration took place at any time during a run, data can be adjusted to reflect the calibration changes as they took place,

— The variables/calibrations current at the time of data dump can be used.

This feature allows comparison of readings for an indication of calibration drift. If improper variables were set, (cell block type, DO membrane type, etc.), corrections can be made by re-dumping with those variables changed to a proper setting.

Selection of the Printer Ready function allows automatic statistical work to be done. Statistics are compiled for each parameter in the form of the number of readings taken, the number of readings taken that were out of the parameter's measurement range, minimum and maximum readings, maximum rate of change between measurements, and mean/standard deviation. Daily statistics, total statistics, both daily/total statistics, or no statistics can be chosen.

If any parameter values are accompanied by an asterisk (*), that value is based on a default calibration setting. This means that the DS3 has forgotten the calibration information provided for the sensor measuring that parameter, and has replaced it with a nominal calibration setting. The affected sensor needs re-calibration, and if the parameter affects other parameters, these will also appear with asterisks (i.e., specific conductance, which affects salinity, DO and depth readings).

Selection of the Spreadsheet Importable function pre-formats data for spreadsheet distribution, quoting all text. This download is accomplished via an X-modem transfer. The Spreadsheet Importable function does not compute any statistics, however.

Erase

The erase function allows a file to be erased to regain use of the memory space occupied by that file.

Setup

This function allows a logging run to be setup. Before starting the logging run, the status of all enabled/disabled parameters should be checked, as well as the status of the stirrer and buzzer. The stirrer and buzzer cannot be altered during a logging run, while calibration and variables can be changed during a run.

To set up a run, the menu calls for the name of the logging run to be entered. It then asks for entry of commencement date/time (in MMDDYY/HHMMSS, and stopping date/time (in MMDDYY/HHMMSS). The program then asks for the time between logging scans (in HHMMSS), and if a warmup is desired prior to commencement of the run. The warmup function allows the DS3 to warmup for 2 minutes prior to the logging run, recommended if a stirrer is used or if DO-pH-Redox sensors are not continuously polarized. Power consumption must be considered. This 2-minute warmup is not necessary if the DO-pH-Redox internal polarizing batteries are used. These batteries continuously power the pH and Redox amplifiers, and the DO sensor, doing away with their 2-minute warmup requirement. A possible shortened life span for the DO sensor must be considered. Even if no warmup is chosen, the DS3 automatically warms up for 30 seconds before beginning a logging scan.

Once a logging run has been set up, the DS3 is disconnected from the interface cables. The transmitter will activate automatically when the logging run starts. It will continue to activate until logging is scheduled to stop, the power supply is depleted, or the memory is full.

Status

This function displays a logging status report. The name and number of each logging run is listed (start/stop/interval). Remaining memory (number of scans/readings based on current parameters) is listed, and remaining battery time (% battery life) is estimated.

Review

This function allows stored data to be scanned without dumping the entire file. The scan can begin at the beginning of a file, the end of a file, or at a specific date and time.

Annotate

This function allows a 49-character annotation to be entered in a text format adjacent to a particular file. The note will then be downloaded along with the file.

Store

This function allows a manual entry of data for a particular situation. If during a survey, the readings for a particular station have stabilized, the data can be immediately stored as a manual file.

- **Header**

Typing an "H" from the Basic Menu allows access to the Header Menu. This causes the header to be printed, and is useful if the Header function has been disabled through the Variables Menu.

The header will appear as:

ABCDEF123456

Time	Temp	pH	SpCond	Salin	DO	DO	Redox	Depth	Batt
HHMSS	deg C	units	ms/cm	ppt	%Sat	mg/l	mv	meters	volts

- **Measure**

Typing an "M" from the Basic Menu allows access to the Measure Menu. Actuating this feature will cause one line of data to be printed immediately. This is useful if the user wants to take occasional discretionary readings.

- **Identify**

Actuation of this feature from the Basic Menu causes the DS3 to print its software version and parameters which the unit will currently support. It will appear as:

Hydrolab DS3 VX.YZ TPCS%ORDB

Power Supply

The internal battery pack uses 10 "AA" batteries, which are contained in the upper part of the unit. The internal battery pack will support a unit for 20 days (stirrer used) or 30 days (no stirrer used). A submersible external battery pack also can be used, and will support the DS3 for up to 140 days, but cannot be used with a stirrer. Power can also be furnished by cable. The power source must remain connected to the transmitter during the logging function.

Unit Configuration

Configuration of a DS3 should be carefully considered. If the Hydrolab LoFlow DO sensor is used, internal polarizing batteries are necessary. This is because the LoFlow DO sensor requires a 5-minute warmup period, and should therefore be continuously powered. If the standard membrane DO sensor is used, a stirrer is necessary unless a flow rate of 25 cm/sec is maintained past the sensor. The 2-minute warmup is sufficient for the standard DO membrane. If the LoFlow DO sensor is used, the weighted sensor guard is used over the multiprobe unit. The stirrer replaces the sensor guard when used, and also provides sensor protection and negative buoyancy.

Deployment

The DS3 is anchored by tying a rope or chain to the stainless-steel bail at the top of the unit. The device should be fixed either upright or level. The unit should be protected from floating debris, and should not be deployed in a location that makes it a navigation hazard. If marked with a buoy, it should not be made attractive to vandals. It is recommended that the multiprobe weighted sensor guard or stirrer be installed, as well as the DO sensor guard. The pH reference electrode should be uncapped. Be prepared to re-calibrate as necessary. The DO membrane may require changing after only a few days. If the unit is stationed in shallow water, there is a danger it could be hit by boats or outboard motor propellers.

DS3 Maintenance

Contaminated or worn out sensors will produce unreliable data. The maintenance manual provides instructions on replacing or servicing worn sensors. This requires careful disassembly of some of the sensors, and re-calibration. A maintenance schedule needs to account for periodic down time for each unit.

APPENDIX C
OPERATING MANUAL FOR THE NISKIN WINGED CURRENT METER

GENERAL OCEANICS

MODEL 6011 MkII

NISKIN WINGED CURRENT METER

OPERATING MANUAL
RAM MEMORY

MARCH 1991

Preliminary

YOUR CURRENT METER SHOULD BE RECEIVED WITH THE FOLLOWING ITEMS.
PLEASE CHECK WHEN UPACKING TO BE SURE THEY ARE INCLUDED.

1. 6011MK2 CURRENT METER
2. VISIBLE SENSORS, PRESSURE & CONDUCTIVITY
3. WIRE MOORING STANDOFF FRAME (W/ANODES) AND WIRE STOP
4. * RAM MEMORY CARTRIDGE
5. OPERATORS MANUAL

*RAM MEMORY CARTRIDGES AND RAM READER KITS ARE PRICED SEPARATELY

IF ANY OF THE ITEMS ARE MISSING, PLEASE CONTACT G.O. ASAP

INC. • 1295 N.W. 163rd Street, Miami, Florida 33169-9922 • Tel.: (305) 621-2882 Telex: 80-8247 Fax: (30

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FIGURES

1 INTRODUCTION

The General Oceanics model 6011 MkII is a battery-powered RAM recording current meter. It measures current by measuring the angle of tilt of its own housing when suspended from a suitable mooring. Wings on the housing orient the meter with the current, the direction of which is then determined by a solid-state flux-gate compass. The absence of rotors and other delicate external sensors, together with its extremely low power consumption, make the meter ideal for long term deployments in the deep ocean, while its small size and ease of handling make it the choice for much inshore work.

The meter incorporates a real-time clock. This means that Universal Coordinated Time (GMT) is recorded with each data point on the RAM cartridge. Log keeping and data analysis are thereby simplified and there is less chance of ambiguity in interpreting the data record. The real-time clock is powered by its own battery, which is separate from the meter's main power battery, and which has a five-year lifetime.

The basic meter records temperature as well as the data for current speed and direction. Sensors to measure conductivity and pressure are also available as options.

In the "Vector-Averaging" mode, the internal microprocessor computes the average east and north components of current from a number of individual readings and records only these averages on the RAM cartridge, a data compression technique which increases the effective capacity of the cartridge by up to thirty-two times. The microprocessor also computes and records the standard deviation of the averages to provide information on the noise environment of the meter. Vector-averaging is the preferred mode of operation. It provides the maximum amount of data and requires the least amount of post-deployment data processing.

After the meter has been recovered the RAM cartridge must be processed. General Oceanics offers the service of reading RAM cartridges and supplying a complete range of data products. Alternatively, the user can acquire a model 6011RR RAM reader to interface with any one of a range of desk-top computers, which allows the user to process the data himself.

General Oceanics can supply auxiliary hardware to facilitate deployment of the model 6011 current meter in a wide range of situations. Deployment from a fixed structure such as an oil rig or harbor pier is the easiest to set up. For near-bottom measurements, a "gallows" frame is available which provides a fixed point mooring at a known height in the water. Most deployments use a wire mooring with either a surface or sub-surface float. For this application a "stand-off" is used, which can be clamped to the wire at any depth without cutting or damaging the wire in any way. The stand-off not only keeps the meter clear of the wire, but also de-couples the meter from mooring motion. Both a standoff and a wire stop are supplied with the meter.

The design of the stand-off and the operating principle of the meter itself both help to simplify mooring design. Being able to clamp the stand-off at any point along the wire makes it easy to re-configure a mooring to meet changing operational require-ments Also, since the meter takes up an angle of tilt determined only by the current, the tilt of the mooring itself is a secondary consideration. This means that, particularly in high current regimes, buoyancy requirements and anchor weights can be greatly reduced.

The meter is normally supplied with a standard fin which covers the speed range zero to 225 cm/sec. For greater resolution at low speeds or to extend the range to higher speeds, low-speed and high-speed fins are available.

2 PRINCIPLES OF OPERATION

2.1 Basis

The Model 6011 MK II current meter is a microprocessor controlled data logger which captures data from a number of sensors and then records them on a RAM cartridge. The overall operation of the meter is best explained by the simplified program flow chart shown in Fig. 1.

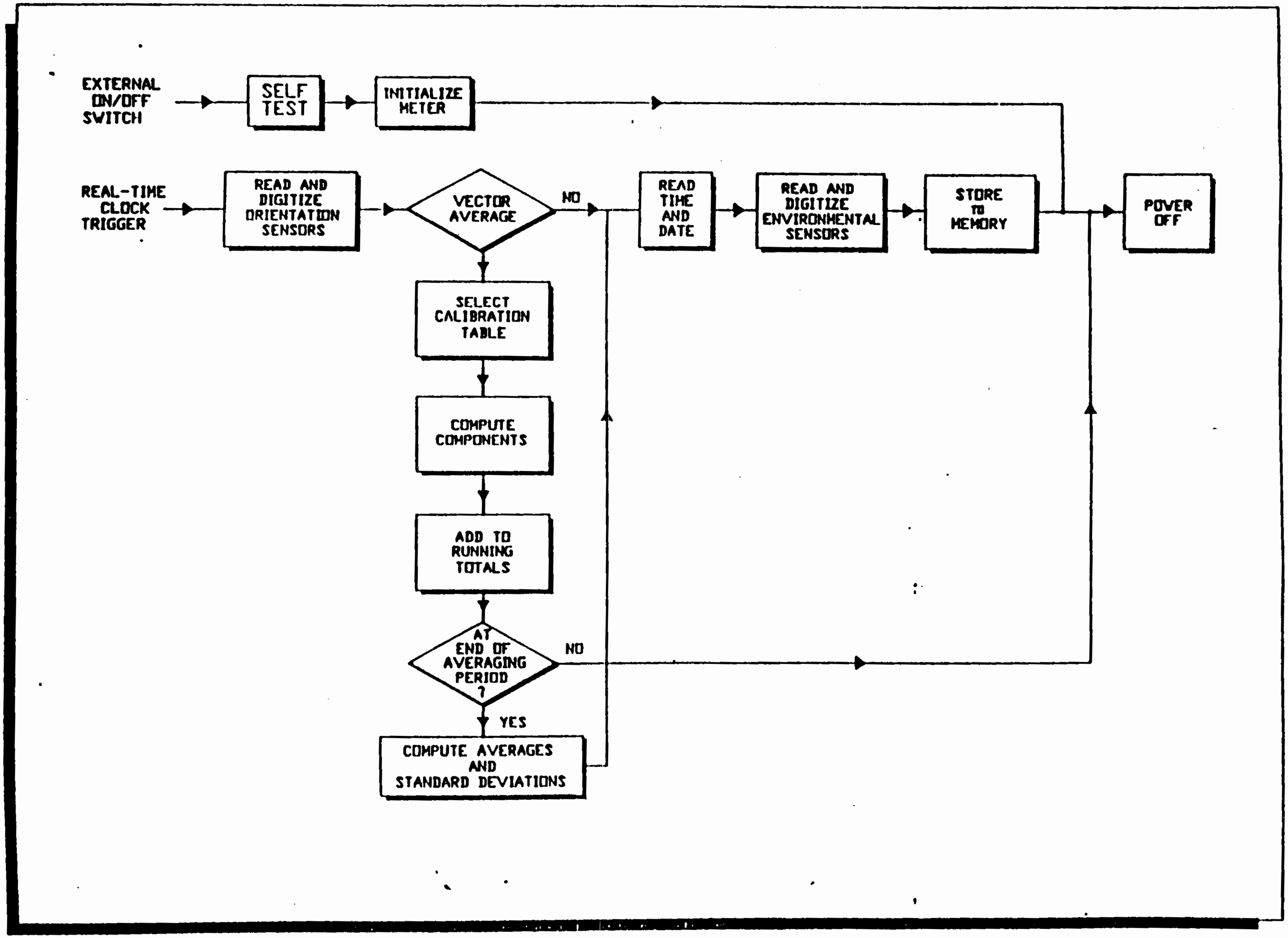

Fig.1 Simplified Program Flow Chart

2.2 Vector Averaging

In the vector-averaging mode, the microprocessor proceeds to compute the north and east components of current immediately after is has read the orientation sensors. To compute the components it needs to know which of the three fins are fitted to the meter. This information is provided by the setting of the mode selector switch: positions 2, 3 and 4 for vector averaging with low, standard and high speed fins. The number of samples over which the average is taken is determined by the setting of the samples-per-burst switch on the real-time clock board. As shown in Fig. 2, a line called "burst status" remains low during the burst period. All the time the status line is low, each component is added to a running total. If it is high, signalling the end of the averaging period, the running total is divided by the number of samples to arrive at the average. Standard deviation is treated in a similar way. The meter then goes on to read the real-time clock and the outputs of the environmental sensors. Each reading is tagged with time and recorded to RAM. Finally the meter is powered down. This means that battery power to the sensors and any other high current components is switched off; only the essential time-keeping components and some of the data memory remain operating. Hence, current consumption between samples is reduced to a few microamps, allowing the meter to operate for up to one year on a single batter. One can see from the last part of the flow chart that time, date and the readings of the environmental sensors that are recorded correspond to the LAST of the samples used to form the vector averages of current, a point that may be significant in data interpretation.

Calibration tables for all three fins are stored in the meter so that if a fin is changed it is necessary to set the mode selector switch to the new position. The tables for meters fitted with pressure and conductivity sensors are slightly different from those without.

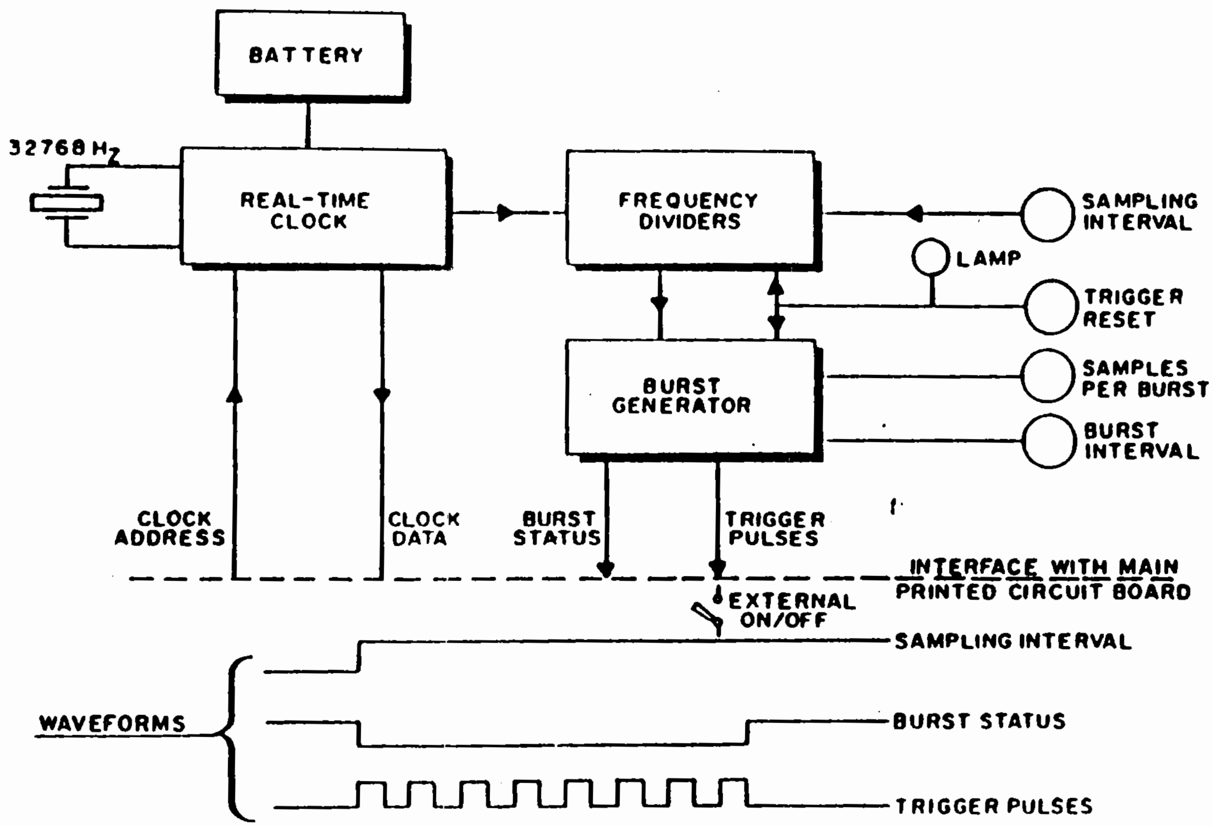

Fig.2 Real-Time Clock. Block Diagram

2.3 Self test

An external ON/OFF switch is mounted on the end cap of the meter's pressure housing. As the hardware block diagram in Fig. 2 indicates, when the switch is in the ON position trigger pulses from the real-time clock are allowed to reach the power control circuitry and the meter cycles through its measuring and recording functions as already described. In the OFF position the meter remains in the quiescent, low power, condition. Turning the switch from OFF to ON triggers a self-test and initialization sequence.

3 CONTROLS AND INDICATORS

3.1 User Operated Controls

The Model 6011 Mk II current meter has a number of user-operated controls which select the various operating modes and sampling intervals. Most of the controls are mounted on the main printed circuit boards (see Fig.3) and are accessible only when the meter is withdrawn from its pressure case. The one external switch is mounted on the end cap opposite to the swivel end. Conductivity and pressure sensors, when fitted, are mounted on the same end cap.

3.2 External ON/OFF Switch

This rotary action switch controls the flow of trigger pulses from the clock board to the main board. In the OFF position no pulses get through and the meter remains in its standby state drawing minimum battery current. In the ON position the meter is triggered into operation at the rate set by the sampling-interval and burst-sampling switches. If the meter is out of its pressure case, the successful progress of the routine can be followed by counting the eight flashes of the self-test lamp.

Normally, this switch will be turned ON or OFF once or twice as part of the check out procedure and then left OFF until just before deployment.

3.3 Sampling Interval

This switch sets the basic sampling interval of the meter in all its operating modes. Operated with the aid of a small screwdriver, this 10-position switch selects intervals from 7.5 seconds to 60 minutes. See SPECIFICATIONS for the full range of available intervals.

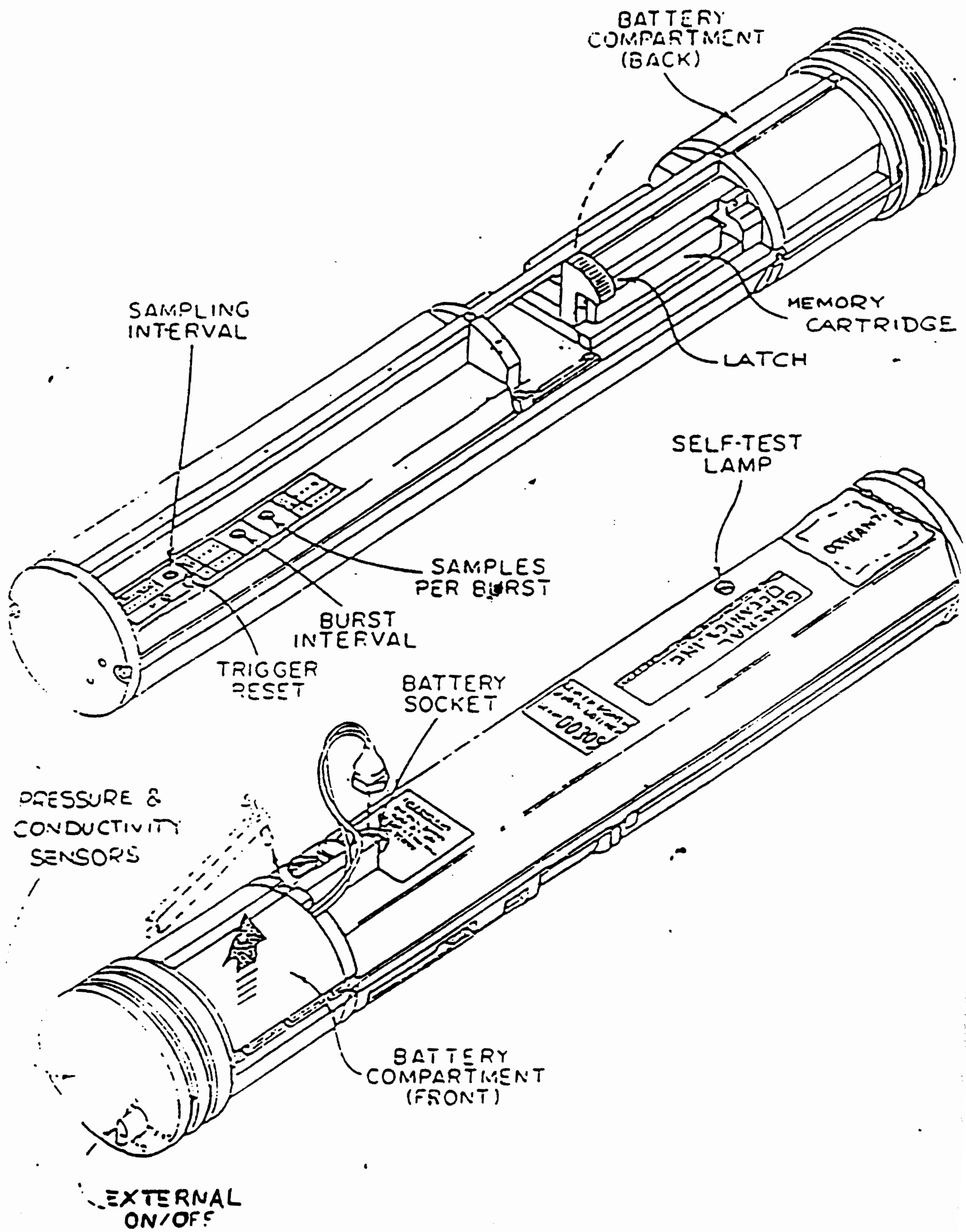

Fig.3 Layout of main features and controls

3.4 Burst Length

A 6-position switch selects the number of samples in a burst. The numbers available are one to 32 in 1:2 steps. This switch selects the number of samples over which the average is taken. In position six, for example, a burst of 32 samples will be averaged before being recorded as a single value. With the switch in position one, the burst length is a single sample.

3.5 Burst Interval

A 4-position switch determines the interval between the samples to be used in a vector average. Thus, if a burst of eight samples and an interval of four seconds are selected, the effective averaging period will be 32 seconds.

3.6 Trigger Reset

Pressing this button resets the counting circuitry so that trigger pulses can be made to occur at a known time in each hour. The general rule is that the first trigger pulse occurs at a time one half of the selected sampling interval after pressing the reset button. If a sampling interval of one minute has been selected, for example, then the first trigger will occur 30 seconds after pressing the trigger reset button, the next at one minute and thirty seconds, the next at two minutes and 30 seconds and so on. The general rule does not apply for the 30 and 60 minute sampling intervals. In both cases the first trigger occurs 22.5 minutes after reset; all the following ones are at the selected intervals.

The red indicator lamp next to the button provides a positive indication that reset has occurred.

The push-button has no effect on the setting of the real-time clock.

3.7 Mode Selector

This switch, mounted on the opposite side of the meter from the other four controls, determines the vector-averaging mode. Position 1 is for factory use. Positions 2, 3 and 4 select the vector averaging mode. Position 2 should be used if a low-speed fin is fitted to the meter, 3 for a standard fin and 4 for a high-speed fin. When computing the vector averages, the microprocessor examines the switch setting in order to select the correct fin calibration look-up table.

3.8 Self-Test Lamp

When the meter self-test is triggered by actuating the external ON/OFF switch, this lamp flashes at the rate of eight times in three seconds as the test proceeds.

4 RAM MEMORY OPERATION

4.1 Introduction

RAM Memory is a solid-state memory system which replaces the more traditional tape recorder and data cassette for long term storage of the data gathered by the current meter. It makes use of a removable data cartridge containing its own 10-year battery power source. The cartridge is smaller than a standard audio cassette, offers up to twice the data capacity, and can be quickly and conveniently changed in the field with no external equipment.

The design of the RAM Memory incorporates a number of features to ensure that recording will take place reliably during a deployment and that data cannot be accidentally erased after a recovery of the meter. For instance, a mechanical interlock prevents the user closing the pressure housing if the cartridge is incorrectly seated in its holder and a self test procedure warns if the cartridge's internal battery has run down. After recovery, a write-protect switch on the cartridge can be set, thus making it almost impossible to inadvertently erase the stored data.

A simple reader is available (6011RR) which plugs into an expansion slot of an I.B.M.* P.C. or PC/XT desktop computer. This, together with software which is supplied by General Oceanics, allows the user to read and process the data stored in the cartridge.

*Registered trademark of International Business Machines Corporation.

4.2 Cartidge Data Capacity

Cartridges are available in nominal capacities of 64, 128, 256 and 512 kilobytes. Each data record in the meter is stored as a 13-byte word. In addition, 13 bytes are used to store the instrument serial number together with some information used internally by the meter itself. Taking as an example a 128 kbyte cartridge, we can now calculate its capacity in terms of data records. The actual size of the cartridge is 131,072 bytes. This leaves 131,059 bytes for useful data, which is equivalent to

10,081 complete data records. The corresponding figures for the other sizes are 5,040, 20,163 and 40,328 data records. The largest capacity cartridge, therefore, allows recording once every ten minutes for almost a full year.

5 INSTRUMENT PREPARATION

5.1 Battery Capacity

First check that there is sufficient battery capacity remaining to run the instrument for the planned deployment period. The only way to be sure of this is by keeping an accurate record of battery use on the label provided on the side of the battery. If there is any doubt, use a new battery. (Refer to section 6.3.1 Battery Life.)

5.2 Battery Replacement

The actual removal and replacement of the battery is very straight forward. The grey plastic battery holder is held in place by a short retaining bar which is secured with a single captive screw. Battery connection is via the blue 5-pin connector at the end of the short pigtail. As the battery holder is being slid into position, take care to guide the pigtail into the slot provided.

5.3 Switch Settings

First select the mode, selector switch. If vector averaging then make sure the switch points to the correct fin . Then set the burst-interval and samples-per-burst switches for the desired averaging period. Thirdly, bearing in mind the constraints pointed out in paragraph 8., select the sampling interval to match the planned deployment period. Finally, press the trigger reset button to lock the triggering sequence in the right phase with the real-time clock.

Again, for many applications, averaging over 32 samples at 2-second intervals (Samples-per-Burst=32: Burst Interval=2sec.) provides good coverage. The sampling interval can be set anywhere between 2 minutes and 30 minutes, depending on the duration of the deployment.

When the instrument has been prepared as just described, activate the external ON/OFF switch to trigger the self test sequence (eight flashes of the self test lamp). Some practice may be needed in positioning the meter so that the self-test lamp can be observed while activating the external switch. If all is well at this stage the switch should be turned off and the meter sealed in its pressure housing.

5.4 Sealing Up

The important points at this stage are (1) place a desiccant bag in the pressure housing, and (2) make sure that the single O-ring seal, and its mating surface, are clean, lightly greased and undamaged. CHECK THAT THE SERIAL NUMBER OF THE HOUSING MATCHES THAT OF THE METER'S ELECTRONICS. Slide the meter carefully into the housing, checking that the battery pigtail is tucked out of the way. Turn the meter so that the alignment hole in the end cap matches the one in the housing. As the meter is driven home, the pin at the end of the meter should engage the locating hole in the far end cap. Secure the meter using the thick nylon monofilament locking cord. It should slide into the matching half-grooves in the end cap and the pressure housing until only the L-shaped termination is exposed. The short end of the L is then pressed into the aligned holes. This ensures that the meter's internal sensors are lined up with the center line of the fin.

5.5 Deployment

After the meter has been prepared as described in the foregoing paragraphs, all that remains is to TURN THE EXTERNAL SWITCH ON and attach the meter to the mooring.

5.6 Fin Change

If the meter is to be used in areas where very high or very low currents are expected, the standard fin can be replaced by one with the appropriate range (see SPECIFICATIONS for ranges available). The fin is secured by two cable ties which rest in grooves in the pressure housing (see section 12.3 for part numbers of replacement ties). The fin is aligned with the meter's direction sensors by the nylon bolt at the swivel end of the housing; the bolt is in turn secured by a locking screw in one of the lugs of the end cap. Note that although the fin can be changed, THE PRESSURE HOUSING AND ELECTRONICS PACKAGE MUST STAY TOGETHER AS A PAIR TO PRESERVE THE ACCURACY OF CALIBRATION.

6 DEPLOYMENT

6.1 Preparing for Deployment

In preparing a meter the user should, in general, follow the procedures detailed in Section 5 (INSTRUMENT PREPARATION) of the Operating Manual.

The mode selector switch (described in section 3.7) should be set to position 2, 3, or 4 depending on whether a low, standard or high speed fin is fitted to the meter.

Fig.1 shows the RAM Memory cartridge in place in the current meter. To plug in the cartridge simply lift the latch, turn the cartridge so the write-protect switch faces outwards, and insert it into the 30-pin socket. If the cartridge is not properly seated, the latch will not spring back to its fully closed position and it will be impossible to slide the meter into the pressure housing.

Finally, set the write-protect switch on the cartridge to OFF, plug in the battery, and turn on the external ON/OFF switch. The meter will then go through a self-test routine as indicated by the Self-Test lamp flashing eight times. If the lamp does not flash, check that the cartridge is properly plugged in with the write-protect switch off.

6.2 Unplugging the Cartrige

When the current meter is recovered at the end of a deployment it will be necessary to remove the cartridge from the meter in order to read it. The cartridge is so designed that is very difficult to lose or alter the stored data while unplugging it. However, to be absolutely sure, the following procedure should be followed:

a) As the meter arrives on deck set the External ON/OFF switch to the OFF position and note the time.
b) Rinse with fresh water and dry the meter as usual.
c) Remove the meter from the pressure housing.
d) Set the write-protect switch on the RAM cartridge to the ON position.
e) Unplug the battery.
f) Lift the latch (see Fig 1) and remove the cartridge from its socket.

All the time the cartridge is out of the meter the write-protect switch should be left in the ON position.

6.3 Other Notes

6.3.1 Battery Life

RAM Memory draws less power from the battery allowing more readings to be taken. For instance, when taking 32-sample averages, the battery has enough energy for 40,000 32-sample averages. So, the maximum deployment time is one year OR the time to record 40,000 32-sample averages OR 80,000 16-sample averages OR 160,000 8-sample averages, whichever is the shortest Note that the 40,000 averages could be recorded in a single deployment using a 512 kbyte cartridge or in a series of deployments using a 128 kbyte cartridge several times.

6.3.2 Last Record Data Loss

The RAM Memory system can loose some data as a result of the averaging process itself. For example in the process of assembling a 32-reading average, the meter is switched off just before taking the 32nd reading 31 data points have been lost.

6.3.3 Monitor Connector

The monitor connector is disabled except for the manufacturers use. To check out a meter, it is a simple matter to record a few minutes' worth of data and then read the cartridge.

6.3.4 Serial Number Record

The first two bytes in the RAM Memory cartridge are used to record the meter's full serial number.

6.3.5 Data Format

Data within the meter are handled as binary numbers, each having sufficient bits to match the required precision. As the data are prepared for recording the individual numbers are stacked end to end to form a string 104 bits long. During the recording process itself the string of bits is stored in the RAM Memory cartridge eight bits at a time as 13 bytes. The bits for each record are organized as follows in the order shown:

Data	Number of Bits
Month	4
Day	5
Hour	5
Minute	6
Pressure	12
Temperature	12
Conductivity	12
East current component	12
West current component	12
Standard deviation in east component	12
Standard deviation in west component	12
Total	104

The way in which each piece of data is encoded and the significance of each bit in the record are as follows:

Number of bits	Vector Averaging
1	1
7	Serial Number
4	Month
5	Day
5	Hour
6	Minute
12	Pressure
12	Temperature
12	Conductivity
12	East Component
12	North Component
12	E. Std. Deviation
12	N. Std. Deviation
112	

7 BATTERY

7.1 Battery Safety

Lithium batteries store a large amount of energy in a small volume so they should always be handled with care. The following rules should be followed:

DO NOT incinerate, short circuit, puncture, crush or disassemble the battery.
DO NOT attempt to re-charge the battery.
DO NOT store or use the battery at temperatures above 72 deg. C.

8 CAUTIONARY NOTES

8.1 Choice of Sampling Interval

When vector averaging, the sampling interval must be long enough to allow the meter to complete its cycle of operation. For example, if a burst length of 32 samples is selected together with a burst interval of two seconds the cycle takes almost 64 seconds to complete. In this case the sampling interval should be no less than two minutes
(since the next shortest interval, one minute, is insufficient to accommodate the complete cycle).

If too short an interval is inadvertently selected the meter automatically compensates, for many combinations of burst length and burst interval, by ignoring the intermediate trigger pulses. However, at best, this can only complicate later interpretation of the data record.

9 SPECIFICATIONS

Speed:
Sensor: Force-balance tilt sensor.
Range: 0 to 300 cm/sec. (with appropriate fin)
Accuracy: +/- 1 cm/sec.
Resolution: +/- 1 cm/sec.

Direction:
Sensor: Three-axis flux-gate compass
Accuracy: +/- 2 degrees.
Resolution: +/- 1 degree.

Temperature:
Sensor: Aged linear thermistor
(Yellow Springs Instrument Co. Type 44202).
Range: -5 to +45 degrees C.
Accuracy: +/- 0.25 Degree C.
Resolution: +/- 1/64 Degree C.
Thermal time constant: < 2 MINUTES

Conductivity:
Sensor: Inductive Toroid
Range: 0 to 75 mS/cm.
Accuracy: +/- 2.5 mS/cm.
Resolution: +/- 0.1 mS/cm.

Pressure:
Sensor: Strain gauge.
Range: 0 to 10,000 p.s.i.
Accuracy: +/- 0.5%
Resolution: +/- 0.1%

Internal clock:
Type: Quartz crystal.
Accuracy: +/- 0.1 second/day
Outputs: Trigger pulses. Date and time information.
Power: Lithium battery independent of meter's main battery. Battery life: 5 years.

Sampling interval:
Selected by 10-position switch.
Available intervals: 7.5, 15, 30, 60 seconds,
2, 5, 10, 20, 30, 60 minutes.

Burst sampling:
Samples per burst selected by 6-position switch;
2, 4, 8, 16, 32 samples per burst.
Burst interval selected by 4-position switch;
2, 4, 8, and 16 seconds.

Data capacity:
Cartridges are available in nominal capacities of 64, 128, 256 and 512 kilobytes. Each data record in the

meter is stored as a 13-byte word. In addition, 13 bytes are used to store the instrument serial number together with some information used internally by the meter itself. Taking as an example a 128 kbyte cartridge, we can now calculate its capacity in terms of data records. The actual size of the cartridge is 131,072 bytes. This leaves 131,059 bytes for useful data, which is equivalent to 10,081 complete data records. The corresponding figures for the other sizes 5,040, 20,163 and 40,328 data records. The largest capacity cartridge, therefore, allows recording once every ten minutes for almost a full year.

Data translation:
Using Model 6011RR reader with desk-top computer (e.g., I.B.M. *P. C. or compatible).

Battery:
Two D-size lithium cells with capacity of 14 amp-hours.
Output: 7.8 volts
Life: up to one year, depending on operating mode.

Pressure case dimensions:
Length: 54.9 cm. Diameter: 10.5 cm.

Weights:
In air: 9/0 Kg. In water: 4.5 Kg.

Pressure Seal:
Single O-ring.
Tool-free opening and closing using General Oceanics' standard plastic cord sealing system.

Exposed material:
Plastic and hard-coat anodized dichromate sealed aluminum.

Wing characteristics:
Low speed: 0 to 70 cm/sec.
Standard: 0 to 225 cm/sec.
High speed: 0 to 300 cm/sec.

10 MOORING METHODS

Figs. 4 and 5 illustrate possible ways of deploying the Model 6011 MkII current meter. Its lightness and compactness considerably ease the expense and difficulty of designing moorings. In deep-sea moorings, especially, the savings are enhanced by the reduced requirements in flotation, anchor weight and cable size.

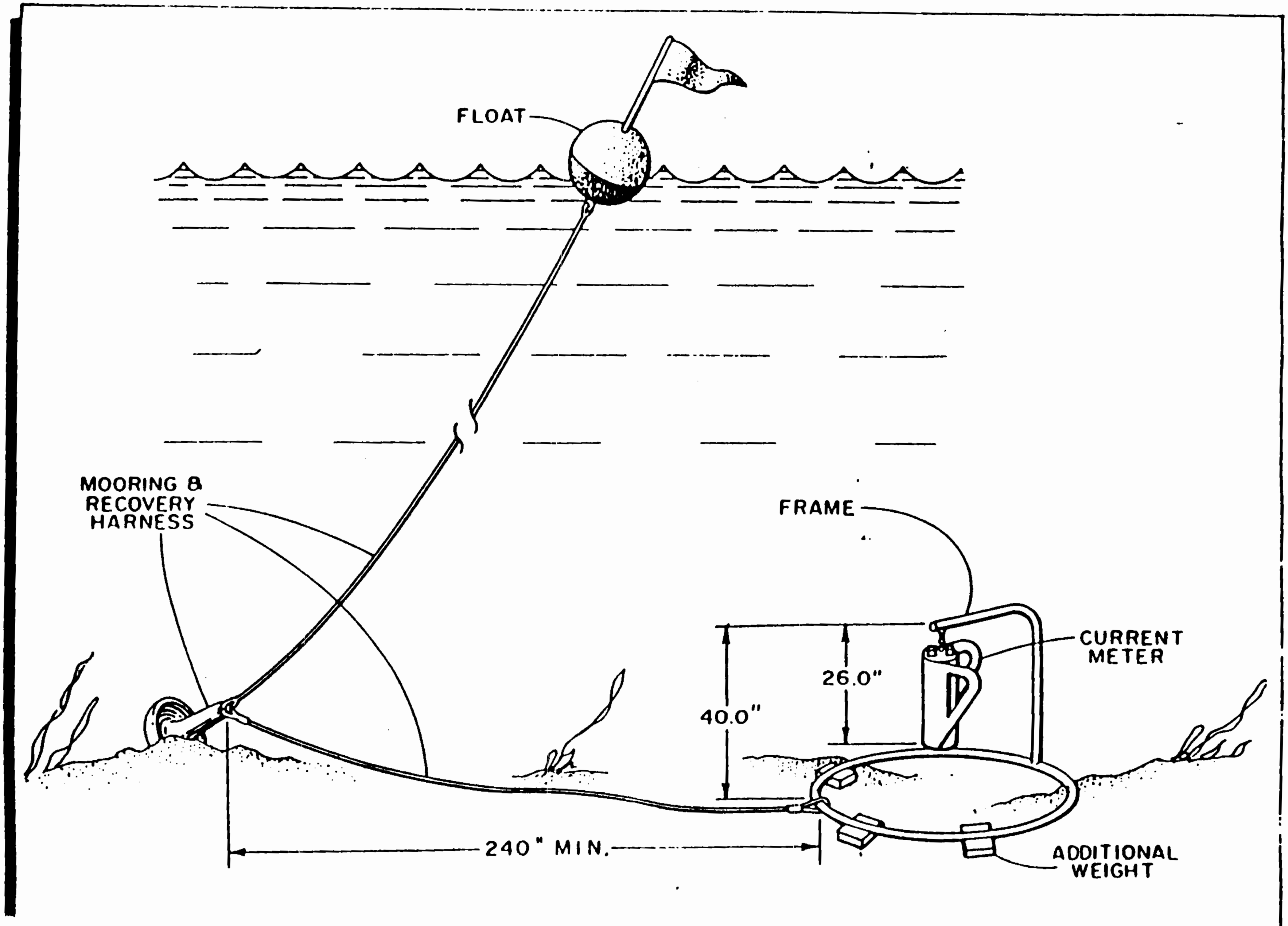

Fig.4 Deployment for Near-Bottom Measurements

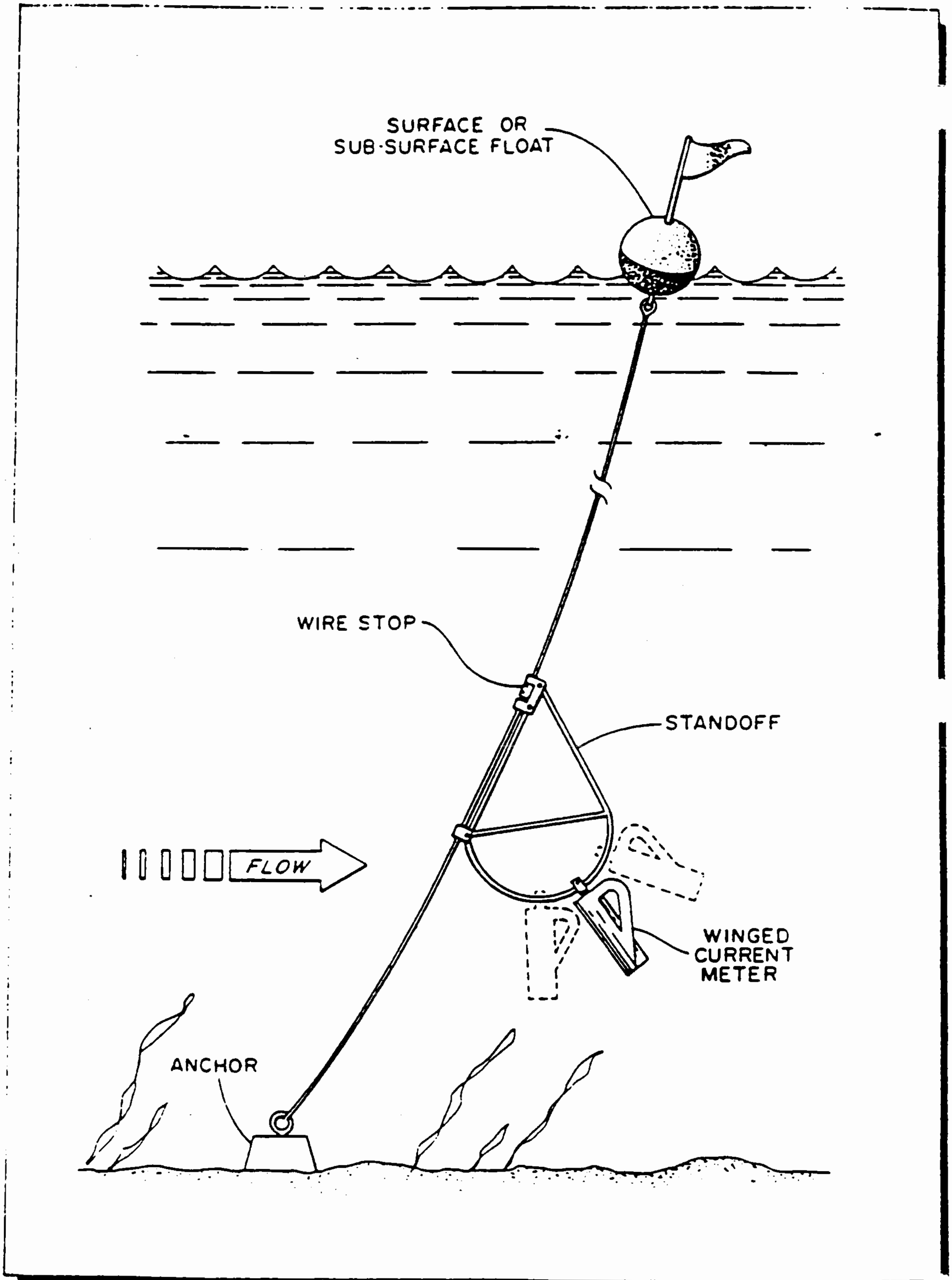

Fig.5 Typical Deep-Sea Deployment

11 CALIBRATION CURVES

On the following pages are six calibration curves showing tilt angle as a function of current speed for the low-speed, standard and high-speed fins. For each speed there are two curves. One is for meters that have no environmental sensors the other is for meters fitted with a conductivity sensor. The addition of a pressure sensor does not change either calibration curve. A temperature sensor is fitted to all model 6011 meters but since it is buried in the end cap, it too has no effect on the calibration curves.

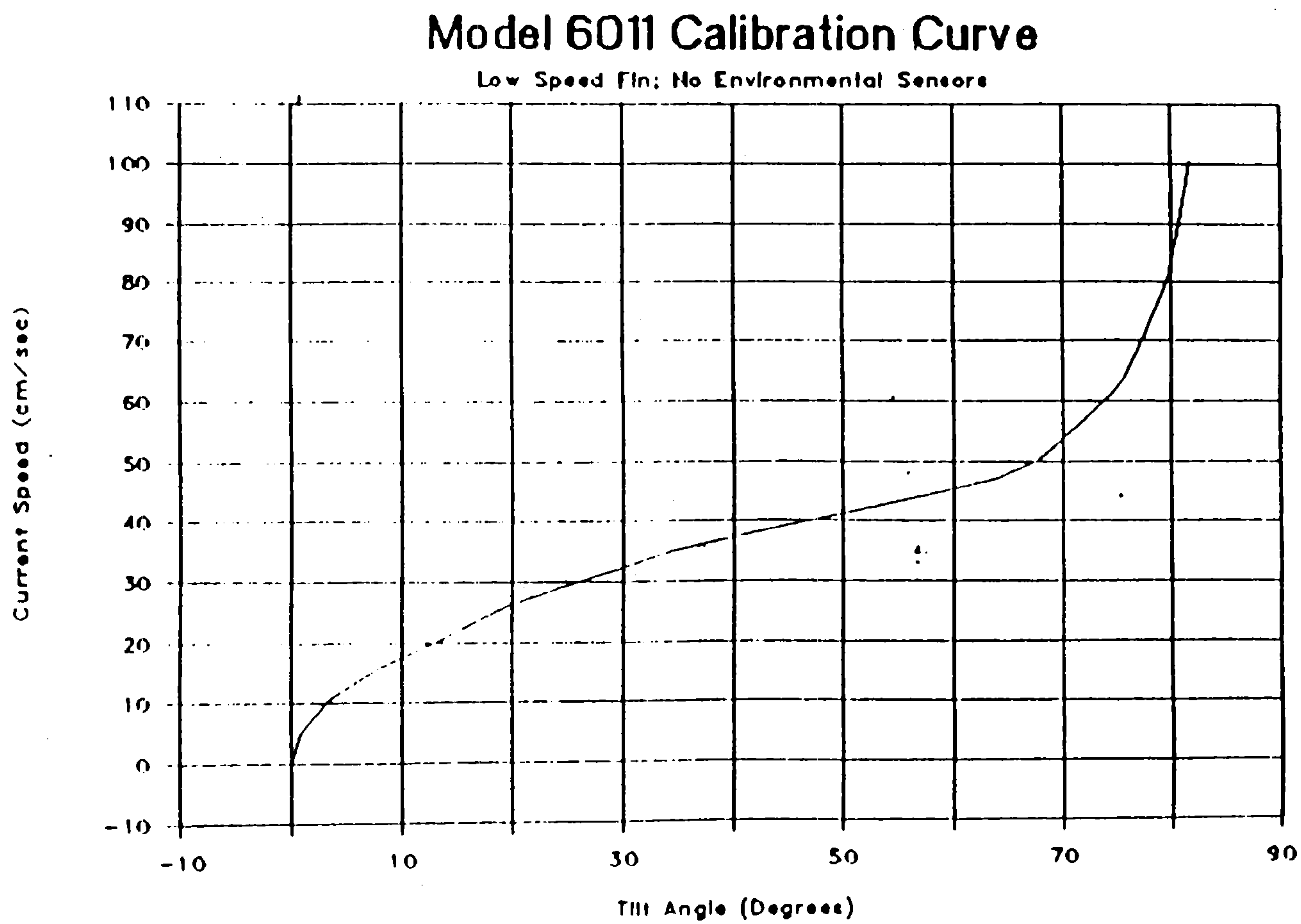

Fig.6 Calibration Curve
Low-Speed Fin: No Environmental Sensors

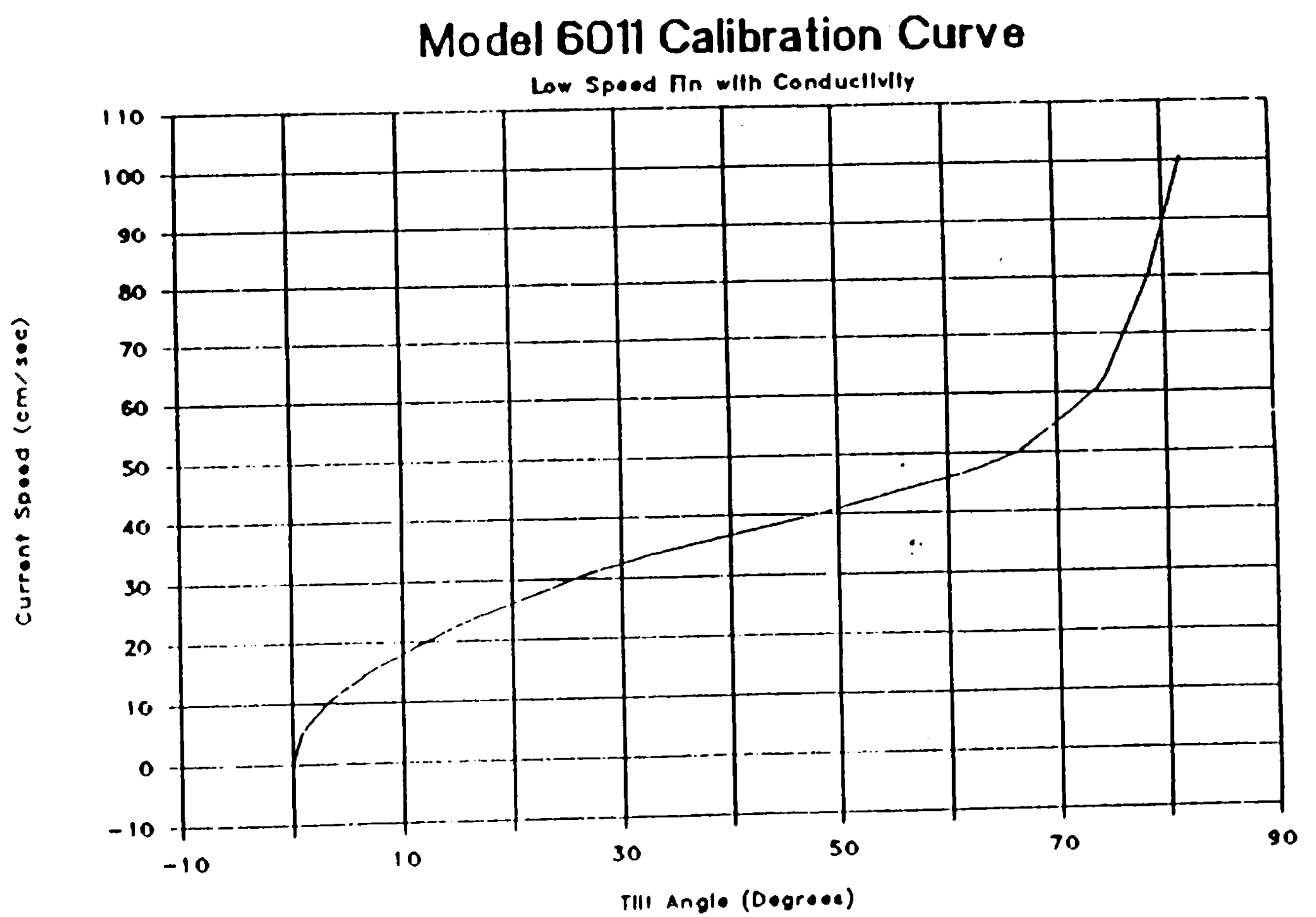

Fig.7 Calibration Curve
Low-Speed Fin with Conductivity

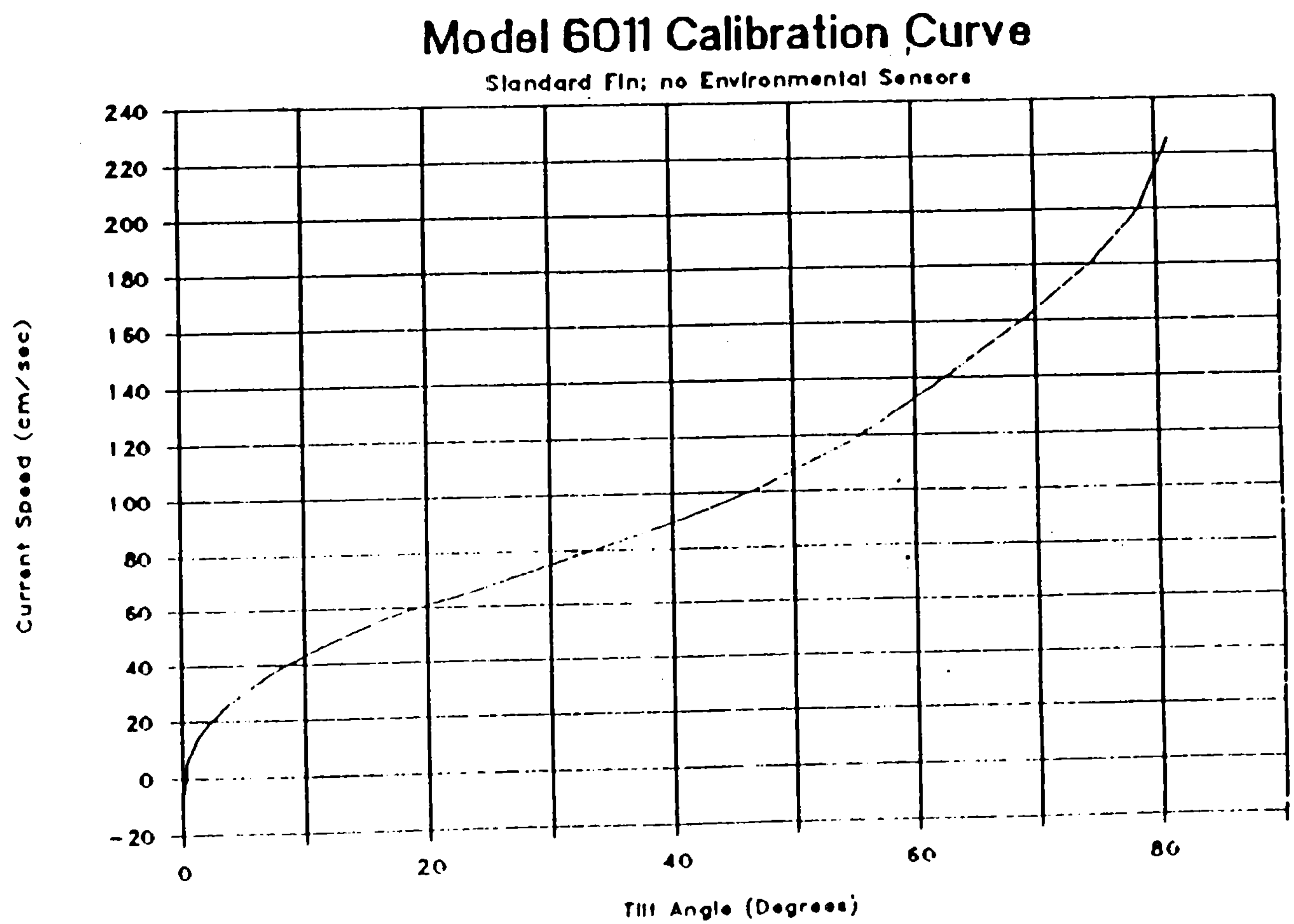

Fig.8 Calibration Curve
Standard Fin: No Environmental Sensors

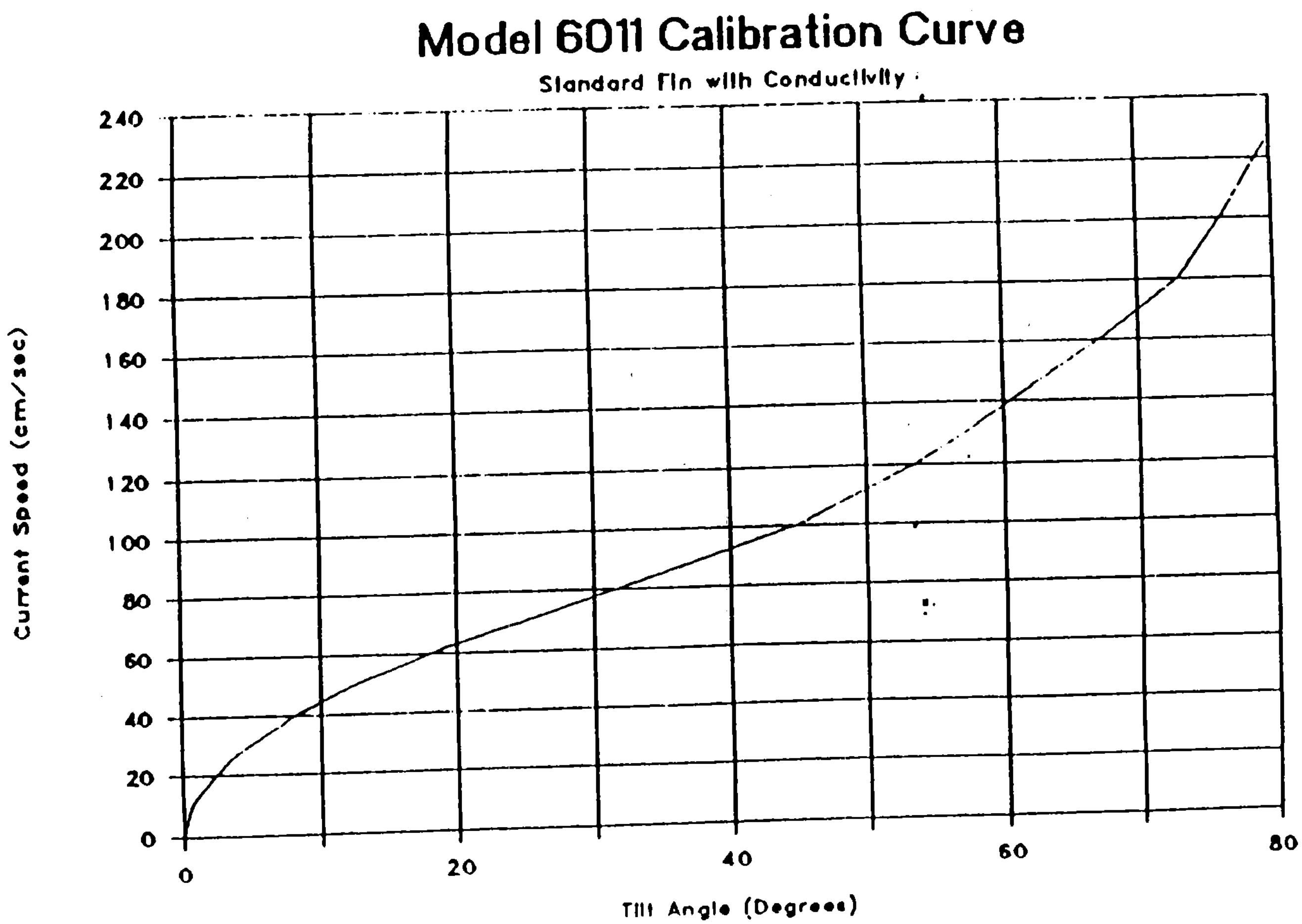

Fig.9 Calibration Curve
Standard Fin with Conductivity

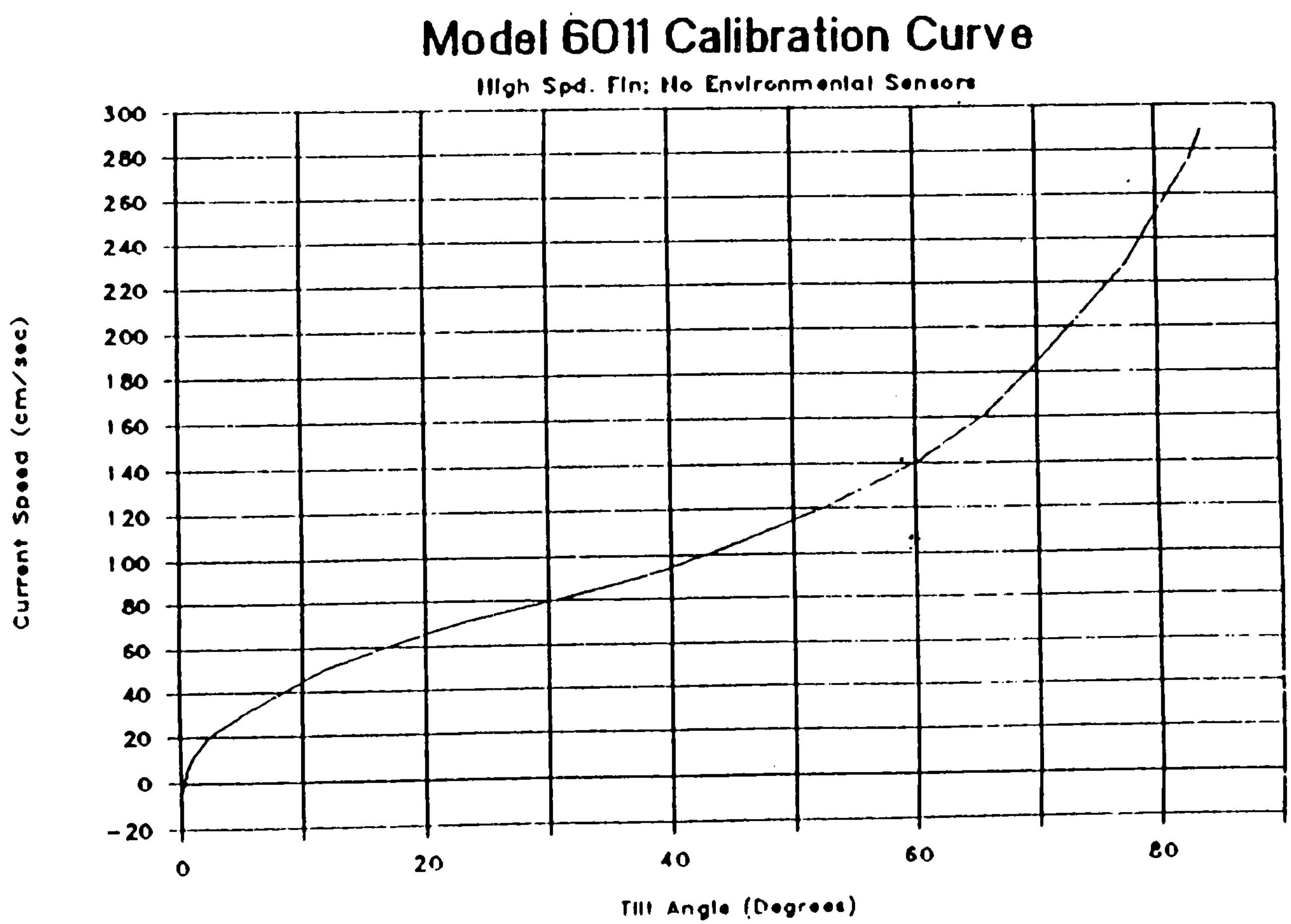

Fig.10 Calibration Curve
High-Speed Fin: No Environmental Sensors

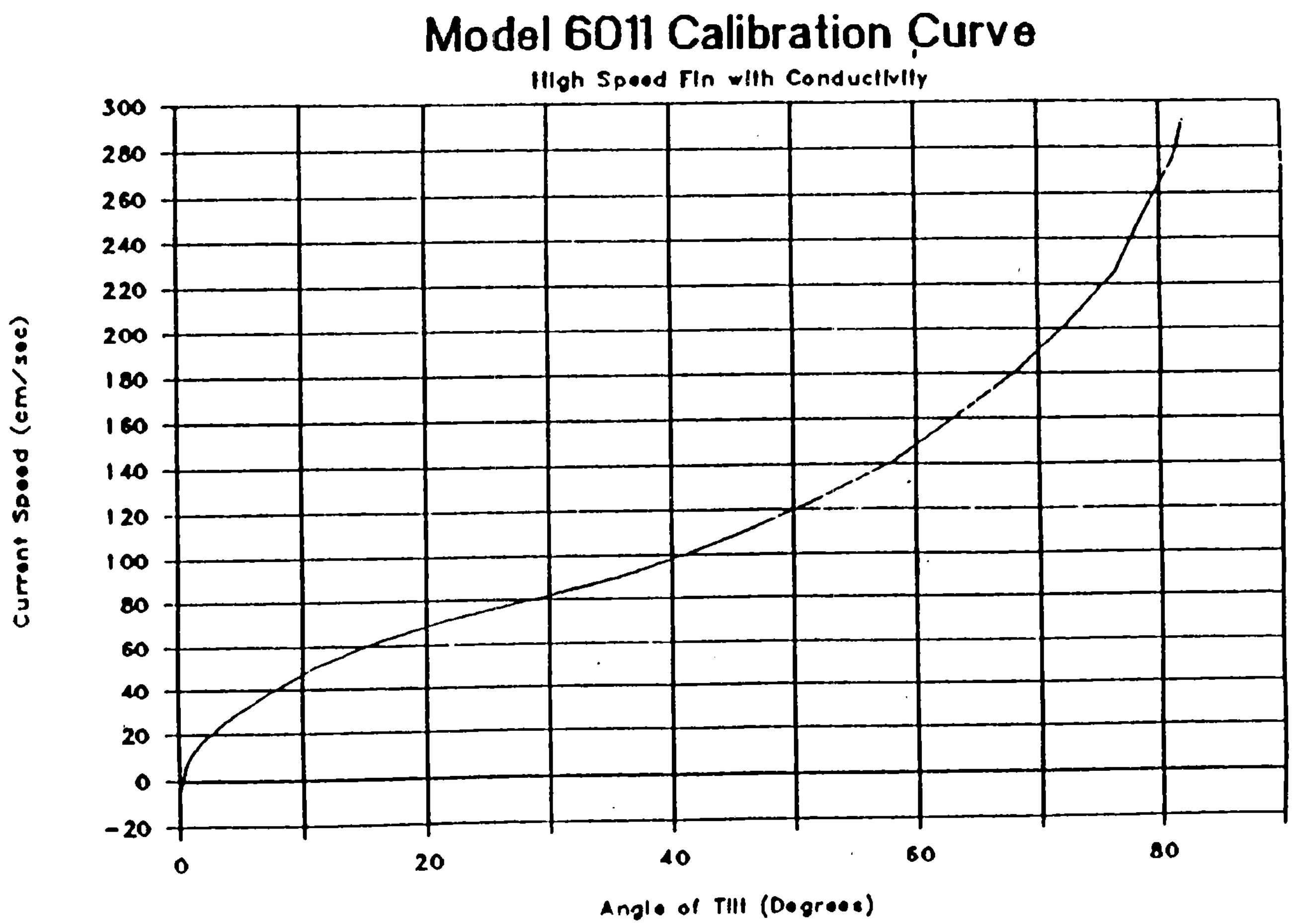

Fig.11 Calibration Curve
High-Speed Fin with Conductivity

12 MAINTENANCE

12.1 Routine Care

Because of its simple design, the Model 6011 requires very little in the way of routine maintenance. The main battery should be replaced as recommended in section 6.3.1 of this manual. The batteries in the real-time clock have a life of five years. Changing these batteries entails removing the protective covers and re-setting the clock using special equipment available only at the factory. For this reason, it is recommended that meters be returned to General Oceanics, Inc. when the clock batteries become due for replacement.

Before each deployment, lightly grease the O-ring seals and check them for damage. If there is any doubt about their integrity, they should be replaced. After a deployment, remove any marine growth, exercising special care in the region of the conductivity and pressure sensors, and thoroughly rinse the meter in fresh water. Remove the main battery and store it separately if the meter is left unused for more than a few weeks.

12.2 Antifouling Treatment

To protect it against marine growth during extended deployments, the meter can be treated with anti-fouling paint. The following procedure uses material which are readily available at boat supply stores and which are compatible with the aluminum of the pressure case and the plastics of the fins. The layers of paint have a negligible effect on meter calibration.

Step 1: Clean housing thoroughly with hot, soapy water and rinse. Allow to dry and wipe thoroughly with acetone to degrease surface.

Step 2: Remove the ABS wing from the current meter pressure housing. Then apply two thin coats of Pettit Metal Primer to the pressure housing, allowing at least 2 hours drying time between coats.

Step 3: Apply two thin coats of Pettit Vinyl Red Undercoater. This forms the prime barrier to protect the aluminum. It is important that two thin coats, instead of one thick one, be used to ensure total coverage of the aluminum. Also apply two coats of undercoater to the ABS wing to ensure better adhesion of the antifouling coating. Remember to leave at least 2 hours between coats. If possible, apply the undercoater with a sprayer. For thinning and cleaning use Pettit # 140 Vinyl Thinner.

Step 4: Applying the antifoulant. Pettit Alumiguard is recommended because of its compatibility with aluminum. The current meter may be painted then shelved for up to 3 months without the treatment loosing its effectiveness. Two or more thin coats should be applied; if expected use is in a high growth area put on up to 5 thin coats. Recoat time is from 1 to 4 hours. Wait at least 16 hours after the last coat before immersion. Remember to coat the wing when using the antifoulant. Pettit # 140 Vinyl Thinner is used to thin the paint and for cleanup.

12.3 Spare Parts

The following are the General Oceanics reference numbers to the more frequently used spare parts.

Item	G.O. Reference #
Standoff	6011SO
Wire Stop	6011WS
O-ring	81-0153
Desiccant bag	99-0611
Cable tie - fin	48-1225
High-speed wing	6011000004
Low-speed wing	6011000003
Standard wing	6011000002
Battery	6011BL

GENERAL OCEANICS

MODEL 6011 RR

RAM READER

OPERATING MANUAL

JANUARY 1991

A COPY OF THIS MANUAL IS INCLUDED ON YOUR FLOPPY DISK

INC. • 1295 N.W. 163rd Street, Miami, Florida 33169-9922 • Tel.: (305) 621-2882 Telex: 80-8247 Fax: (30

GENERAL OCEANICS

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1 INTRODUCTION

1.1 Function

The General Oceanics Model 6011RR RAM Reader is designed to read the data cartridges used on the 6000 series of oceanographic recording instruments. These data cartridges contain banks of CMOS memory chips together with a lithium battery which allows them to retain recorded data for over ten years. The Reader plugs into an IBM PC/XT, or compatible, desktop computer. Data are taken from the cartridge, displayed on the computer screen, and recorded on a disk file. The user can then access the file and carry out any further processing he wishes.

2 INSTALLATION

2.1 Component Parts

The Model 6000RR is shipped as a package of four items:

1. The RAM Reader main unit. This holds the socket int(which is plugged the data cartridge.

2. An interface card which plugs into one of the expansion slots in the IBM PC/XT. (MetraByte Corp. Model PIO-12)

3. A ribbon cable with 37-pin connectors to connect items 1 and 2.

4. The floppy disk containing the operating and installation software.

2.2 Hardware Installation

2.2.1 Base Address Selection

The IBM PC/XT accesses the interface card by way of four consecutive address locations in the PC I/O address space. These addresses start at a base address which is selected by an 8-position DIP switch (see Fig.1). The base address can in theo be placed anywhere in the I/O address space, but base addresses below FF hex (255 decimal) should be avoided as this address range is used by the internal I/O of the computer. The 200-3FF hex (512-1023) address range provides extensive unused areas of I/O space, though you should check with page 2-23 of the "Technical Reference Manual" for possible conflicts with com installed peripherals.

```
           9 8 7 6 5 4 3 2
         _________________
ON               * * * * * *
/\         ¦ ¦ ¦ ¦ ¦ ¦ ¦ ¦
¦¦         * *
         -----------------
```

Fig.1 Base address switch setting for 300 hex (768 decimal)

TABLE I. Switch Position Address Equivalents.

Switch posn.	Address line	Decimal equivalent
9	A9	512
8	A8	256
7	A7	128
6	A6	64
5	A5	32
4	A4	16
3	A3	8
2	A2	4

Switches have decimal values as shown above, in the "off" position. In the "on" position the decimal value is zero.

Conflict with other peripherals that may be installed often manifests itself as erratic data displayed on the screen, in which case a different base address should be selected.

2.2.2 PIO Card Installation

Turn off the computer, disconnect the power cords, and move it so that you can work on it from the back. Open the computer and remove the screw holding the filler plate that is in line an empty expansion slot. Remove the filler plate and plug the interface card into the slot making sure it is seated firmly in the connector. Finally, secure the card bracket with the screw that was removed earlier, and return the computer to its case. You can now proceed to install the software.

2.2.3 System Assembly

Position the RAM Reader main unit alongside the computer foı convenient access. Use the 37-way ribbon cable to connect it to the interface card in the computer.

2.3 Software Installation

2.3.1 Introduction

The diskette supplied with the RAM Reader contains a number of programs and files. MANUAL.DOC contains the text ı this manual. The second is a program labelled SETUP; it allows the user to select which disk drive will be used to store the data that is read from the RAM cartridge. It also tells the actual reading programs the base address that has been selected on the interface card. The remaining files contain the programs which control the reader and format the data (e.g. RDCM will rea(the RAM cartridge from a MKII Current Meter). These programs ar(all very similar and differ only because different instruments iı the 6000 series use slightly different data formats (see Section 3).

2.3.2 Running SETUP

First you should make a working copy of the software disk supplied, using the normal DOS commands. The original disk can then be stored as a back-up.

At this stage it is worth giving some thought to the genera arrangement of your data handling system. The overall aim is to transfer data from the RAM cartridge to a disk file on either a floppy or hard disk. Once in a disk file the data can be accesse much more quickly and conveniently than by re-reading the cartridge. For a system with two floppy disks, it will normal. be most convenient to run the program disk in drive A: and to store the transcribed data on a separate disk in drive B:. With hard disk system, running the program on the hard disk - drive C: - and storing data on a floppy disk in A: may be best.

Whatever arrangement you use, transfer all the files on the General Oceanics disk to the selected drive, either by inserting the floppy disk in the drive or by copying them to drive C:. Then make the selected drive the default drive (e.g. if C: then type 'C:' followed by RETURN). Then type 'SETUP' followed by RETURN. After a few seconds you will see the introductory banner followed by a prompt to select the data storage disk drive. Make your selection, following the guidelines in the opening remarks of this section.

The next prompt calls for the entry of the base address which you have already selected on the DIP switch on the interface card. Enter this address as a decimal number.

Once you have entered these two pieces of information they are stored in a file SETUP.DAT on the default drive. There is no need to run the SETUP program again unless you wish to change these initial conditions.

2.3.3 Reading Data

To read data, type the appropriate program name followed by RETURN. The program name can be found in Section 3, DATA FORMAT, under the name of the instrument on which the data were recorded. For example, if data were recorded on a Model 6011 MK II current meter, then the program to use is RDCM.

The program will start by displaying the following information:

a. The serial number of the recording instrument.

b. The number of samples stored in the cartridge.

c. The disk drive being used for data storage.

The program will issue a warning if you attempt to read data without a cartridge plugged into the reader, or if the reading program does not match the recording instrument i.e. if you try to read Current meter data with the Inclinometer program.

To proceed, follow the prompts as they appear on the screen. Reading will continue until all the samples have been read or until you reach the last address in the cartridge.

The default read operation will display the date/time group and the orientation sensor data on the screen along with the number of samples. Using the "h" key to halt the process other options become available.

They include:

- "s" - to start the read process at the beginning of the cartridge (re-starting will write over previously stored file!) ;
- "c" - to continue process at present position (always continues in default mode);
- "o" - to display the environmental sensors (instead of orientation data) continuing from present position;
- "b" - blanks the screen while processing (speeds up operation considerably);
- "e" - terminate processing at present position.

Since the generated file is an ASCII delimited file it can reach quite a size with respect to the number of bytes. If you have designated a floppy drive as the storage drive then the program will pause after each group of 5000 readings to allow you to change diskettes if necessary. Hard disks 'C' through 'F' will continue to write the data until the cartridge end is reached.

The following table will help to determine the correct floppy disk size and whether to replace it or to continue:

Cartridge Size	Readings Available	Size of file (bytes)	Disk size
64K	5,000	300,000	360K min.
128K	10,000	600,000	720K min.
256K	20,000	1,200,000	1.2Meg. min.
512K	40,000	2,400,000	10Meg. Hard drive

(The above examples are for a MKII Current Meter which averages about 60 bytes per reading).

2.3.4 Examining Data

The data file (e.g. CM2DAT.DAT) can be viewed using a number of different methods. DOS utilities MORE, TYPE, EDLIN and PRINT are bottom line methods of viewing, editing and printing the data. Any word processor capable of handling ASCII files can be used also. The file can also be imported into any number of spreadsheet and database environments available commercially.

Section 3 of this manual gives the data format and respective column designations for instruments in this series.

3 DATA FORMAT

3.1 Common Features

The format of the data displayed on the screen will vary from instrument to instrument. However, certain features remain common through out the range. Columns 1 through 4 are used to display the month, day, hour and minute recorded by the instrument's real-time clock. The last column is the sequential sample number. The columns in between display data as described in the sub-sections relating to each instrument.

Data are recorded on the disk file in essentially the same format as the display except that there are no spaces and no column headings. Data values are separated by commas and each line is terminated by a carriage return.

3.2 Model 6011U Inclinometer

The program to read data from Model 6011U Inclinometers is RDINC. For a Model 6011UP (an inclinometer fitted with a pressure sensor) use RDINCP.

The file used to store cartridge data is INCDAT.DAT.

Data are stored on disk as twelve columns. The first four and the twelfth are as described in Section 3.1. Column 5 is used to store pressure as a percentage of the sensor's full scale reading. Column 6 stores temperature in degrees Centigrade. Column 7 represents conductivity in units of milliseimans/meter.

Columns 8 and 9 are used to store tilt angle (relative to the vertical) and tilt direction (relative to magnetic north), both in degrees.

Alternatively, columns 8 and 9 can be used to store tilt information in Cartesian form as easterly and northerly components. These components are derived, in principle, as follows. First the tilt angle is converted to its trigonometric sine - a number in the range zero to 1. Then, this number is multiplied by the sine of the direction angle to obtain the easterly component. Similarly, the northerly component is sin(tilt) multiplied by cos(direction). We end up, therefore, with numbers in the range -1 to +1. On this scale -1 in the column 9 would represent 90 degrees of tilt to the south. The Cartesian representation has an advantage, in some applications, of allowing tilt angles to be handled vectorially.

The tenth and eleventh columns are values of the standard deviations of the two tilt components.

If conductivity or pressure sensors are not fitted to the inclinometer, dummy data will be stored in the corresponding columns on the disk.

3.3 Model 6011 MkII Current Meter

The program to read data from the Model 6011 MkII Current Meter is RDCM.

The file used to store cartridge data is CM2DAT.DAT.

Data are displayed in 12 columns as follows:

Column	Data
1	Month
2	Day
3	Hour
4	Minute
5	Pressure (as % FSD of sensor)
6	Temperature (deg. C.)
7	Conductivity (mS/m)
8	East-West current (cm./sec.)
9	North-South current (cm./sec.)
10	E-W Std. Devn. (cm./sec.)
11	N-S Std. Devn. (cm/sec.)
12	Sample Number

3.4 Model 6070 Thermograph

The program to read data from the Model 6070 Thermograph is RDPTC.

The file used to store cartridge data is DATLOG.DAT

Data are displayed in 8 columns as follows:

Column	Data
1	Month
2	Day
3	Hour
4	Minute
5	Pressure
6	Temperature
7	Conductivity
8	Sample Number

3.5 Model 6051 Pressure Gauge

The program used to read cartridges from the Model 6051 Pressure Gauge is RDPG.

Data are stored in DATLOG.DAT.

APPENDIX D

ANALYTICAL METHODS, SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material[a]	Sample Preservation[b]	Holding Times
Hardness	USEPA 130.1	Water	(1) 500-ml Plastic Jar	Chill, 4° C, HNO_3 pH < 2 (.25 ml)	28 days after sampling
Total Suspended Solids (TSS), non-filterable	USEPA 160.2	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum[c]	Chill, 4° C	7 days until analysis
Alkalinity	USEPA 310.1	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum[c]	Chill, 4° C	14 days until analysis
Nitrate-N	USEPA 352.1	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C	2 days until analysis
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill, 4 C	2 days until analysis
Total Kjeldahl Nitrogen	USEPA 351.4	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C, H_2SO_4 pH < 2 (.25 ml)	28 days until analysis
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill, 4° C	28 days until analysis

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material[a]	Sample Preservation[b]	Holding Times
Total Phosphorus	USEPA 365.3	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	H_2SO_4 pH < 2	Analyze within 28 Days
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill, 4° C	Analyze within 28 Days
Biological Oxygen Demand (BOD)	USEPA 405.1	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C	Start analysis within 48 hours
Chemical Oxygen Demand (COD)	USEPA 410.1	Water	(1) 500-ml Plastic Jar	Chill, 4° C, H_2SO_4 pH < 2 (.25 ml)	28 days until analysis
Total Organic Carbon (TOC)	USEPA 415.1, 415.2	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C, H_2SO_4 pH < 2 (.25 ml)	28 days until analysis
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill 4° C	28 days until analysis
Cation Exchange Capacity (CEC)	USEPA 9081	Soil	Shelby Tube	None	None
Heterotrophic Plate Count	SM 9215B	Water	(1) 1-liter Amber Glass Jar with Teflon-lined septum (sterilized)	Chill, 4° C	Not to exceed 24 hours
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar (sterilized)	Chill, 4° C	14 days

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material[a]	Sample Preservation[b]	Holding Times
Metals by Inductively Coupled Argon Plasma (ICAP) Spectroscopy	USEPA 6010	Water	(2) 500-ml HDPE jar	Chill, 4° C, HNO_3 pH < 2	6 months
		Soil	(1) 4-oz HDPE jar	Chill, 4° C	6 months
Metals by Grapite Furnace Atomic Absorption (GFAA)	USEPA 7000 Series	Water	(2) 500-ml HDPE jar	Chill, 4° C, HNO_3 pH < 2	6 months
		Soil	(1) 4-oz HDPE jar	Chill, 4° C	6 months
Mercury by Cold Vapor Atomic Absorption (CVAA)	USEPA 7470	Water	(2) 500-ml HDPE jars	Chill, 4° C, HNO_3 pH < 2	28 days
	USEPA 7471	Soil	(1) 4-oz HDPE jar	Chill, 4° C	28 days
Cyanide	USEPA 9010	Water	(1) 500-ml HDPE jar	Chill, 4° C, NaOH pH > 12[f]	14 days
		Soil	(1) 4-oz HDPE jar	Chill, 4° C	14 days
Volatile Organic Compounds (VOC)	USEPA 8240	Water	(3) 40-ml vials with Teflon-lined septa	Chill, 4° C, HCl pH < 2, store in dark[e]	14 days
		Soil	(1) 4-oz Glass Jar with Teflon-lined septa	Chill, 4° C, store in dark	14 days

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	**Analytical Method**	**Sample Matrix**	**Minimum Container Size / Material[a]**	**Sample Preservation[b]**	**Holding Times**
Semivolatile Organic Compounds (SVOC) (Base-Neutral/Acid Extractables)	USEPA 8270	Water	(2) 1-liter Amber Glass Jars with Teflon-lined septa	Chill, 4° C[c]	Extract within 7 days, analyze within 40 days
		Soil	(1) 4-oz Glass Jar with Teflon-lined septa	Chill, 4° C	Extract within 14 days, analyze within 40 days
Chlorinated Pesticides/PCBs	USEPA 8080	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C[c]	Extract within 7 days, analyze within 40 days
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C, store in dark	Extract within 14 days, analyze within 40 days
Chlorinated Herbicides	USEPA 8150	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C[c]	Extract within 7 days, analyze within 40 days
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 14 days, analyze within 40 days

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material[a]	Sample Preservation[b]	Holding Times
Organo phosphorous Pesticides	USEPA 8140	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C[e]	Extract within 7 days, analyze within 40 days
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 14 days, analyze within 40 days
Dioxins	USEPA 8290	Water	(2) 1-liter Amber Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 30 days, analyze within 45 days of collection
		Soil	(1) 8-oz Glass Jar with Teflon-lined septum	Chill, 4° C	Extract within 30 days, analyze within 45 days of collection
Hexavalent Chromium	USEPA 218.4	Water	(1) 1-liter Plastic	Chill 4° C	24 hours
		Soil	(1) 4-oz Glass Jar (1) 1-liter Glass Jar	Chill 4° C	None specified
Percent Moisture	ASTM D-2216-80	Soil	Shelby tube	None	None
Bulk Density	ASTM D-4253	Soil	Shelby tube	None	None
Porosity	ASTM D-4645	Soil	Shelby tube	None	None

Analytical Methods, Sample Containers, Preservation, and Holding Times					
Parameter	Analytical Method	Sample Matrix	Minimum Container Size / Material[a]	Sample Preservation[b]	Holding Times
Grain Size	ASTM D-2434	Soil	Shelby tube or Stainless Steel Sampling Sleeve	None	None
Specific Gravity	ASTM D-854	Soil	Shelby tube	None	None
Permeability	ASTM D-2434	Soil	Shelby tube	None	None
Volatile Organic Compounds in Ambient Air	T014	Air	Summa canisters	None	None

Notes:

a Soil samples collected with split-barrel samplers shall be submitted to the laboratory in stainless steel sampling sleeves.

b Any preserving agents used must be ACS Certified Reagent Grade.

c Hardness and chemical oxygen demand (COD) will be collected in same sample container.

d Total suspended solids, sulfate, orthophosphate, and alkalinity will be collected in same sample container.

e Sodium thiosulfate ($Na_2S_2O_3$), 0.008%, should be added in the presence of free or combined chlorine.

f Sodium arsenite or ascorbic acid if oxidizing agents are present.

N/A Not applicable. Extraction is not required or is part of the analytical method.